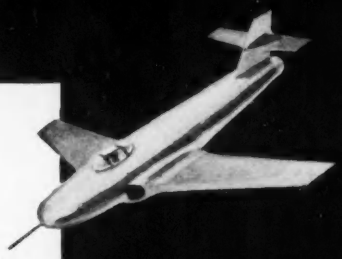
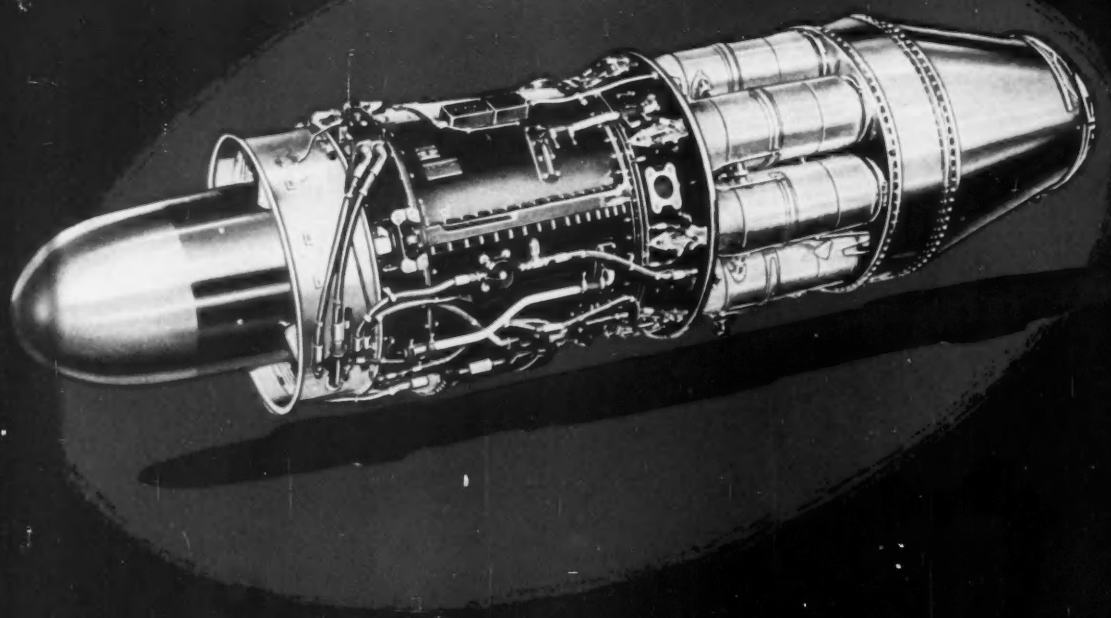
ANALYZING HYDRAULIC MOTOR PERFORMANCE

SHARON STAINLESS

HAS WHAT IT TAKES FOR MODERN AIRCRAFT PRODUCTION





Where parts must be light in weight, yet absorb the heavy punishment of high speeds, high temperatures, and corrosive elements, they can be better made of Sharon Stainless Steels.

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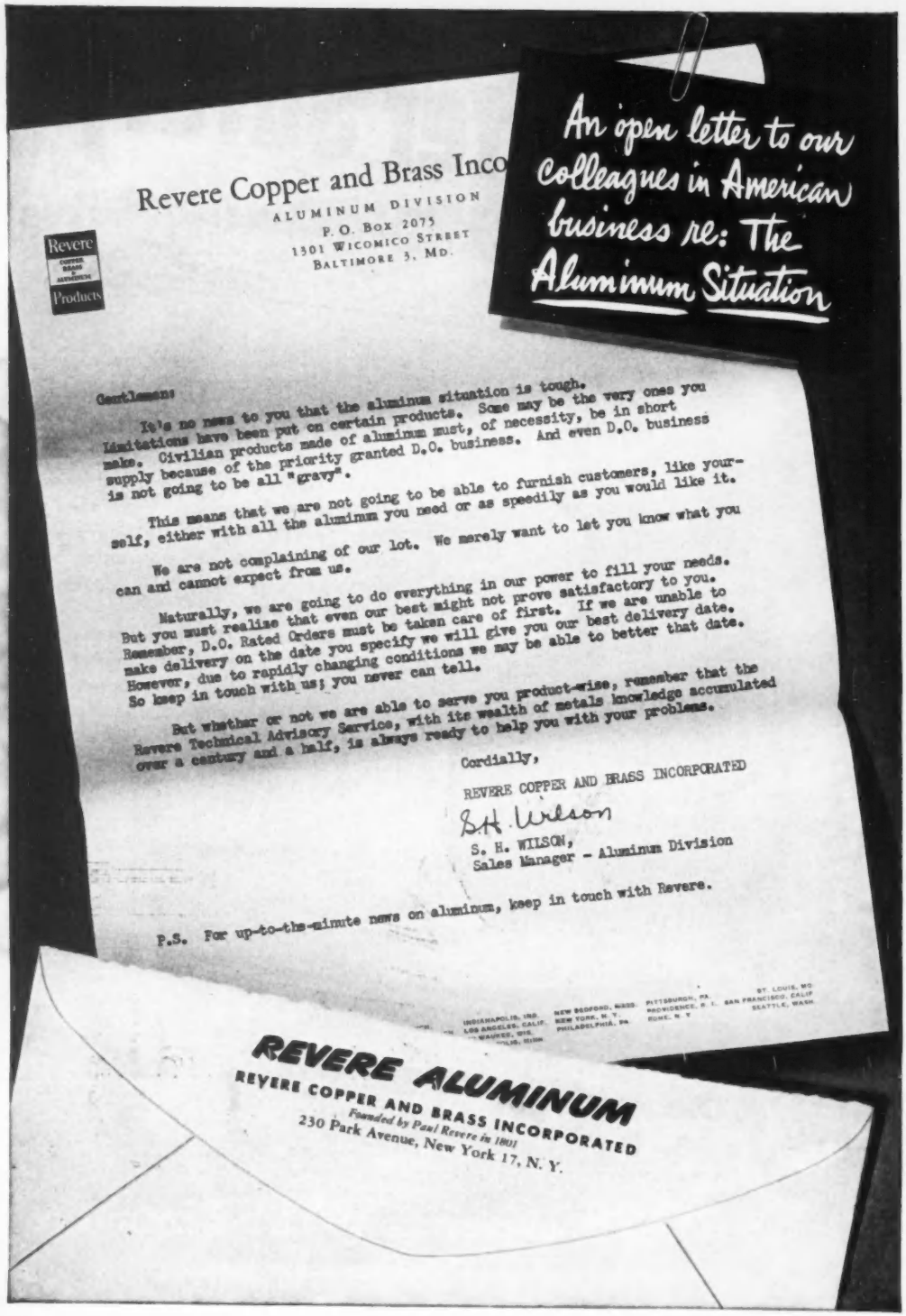
An open letter to our colleagues in American business re: The Aluminum Situation
Revere Copper and Brass Inco
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Baltimore 3, Md.
Revere
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Gentlemen:
It's no news to you that the aluminum situation is tough.
Limitations have been put on certain products. Some may be the very ones you make. Civilian products made of aluminum must, of necessity, be in short supply because of the priority granted D.O. business. And even D.O. business is not going to be all "gravy".
This means that we are not going to be able to furnish customers, like yourself, either with all the aluminum you need or as speedily as you would like it.
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VOLUME 22

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NUMBER 4

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are available with two types of easy-mounting brackets . . . for on-the-motor and for off-the-motor mounting. They simplify assembly, provide you with a ready-made means for dependable and easy attachment.

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Careful checking showed that every one was ready for use, without re-working of any kind . . . and Mallory kept the production line rolling by arranging for shipment from one customer to the other. Mallory craftsmanship and production methods had insured the capacitors against deterioration.

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Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

NONMETALLIC MATERIALS

TWO LAYERS of plastic film with metal foil between are being used as collapsible tube containers for a variety of products. The choice of plastic--vinyl, polyethylene, Pliofilm, Saran, neoprene rubber or coated cellophane--depends on the material being packaged and the type of appearance desired.

BAKING ENAMEL resists temperatures as high as 400 F, thus making it applicable to such products as stoves and metal lamp shades. Bond is satisfactory on steel, aluminum, brass, chrome plate, gold and silver. Finish is non-yellowing, mar-resistant and unaffected by solvents. Comes in wide range of colors; has glossy or flat finish.

SURFACE COATINGS for polished steel, aluminum, zinc and zinc-plated steel have appearance similar to that of copper, brass or bronze. Shortages of the latter may switch emphasis to this combination. Transparent coloring material and vehicle can be varied to fit a given color scheme and production facility.

PHOTOELECTRIC CELLS will need strong glasses if they are to be as sensitive as special cadmium sulphide crystals recently perfected. The newcomers are 1,000 times more sensitive than standard photo cells and will make possible automatic X-ray inspection that is super-thorough, yet high speed to the tune of 600 units per minute.

LIGHTWEIGHT glass-reinforced polyester tubing, pipe and rod of high physical strength may find many uses as structural and electrical components. Average test results are: as pipe--bursting pressure is 75,000 psi; as hollow column--compressive strength is 30,000 psi; as hollow beam--modulus of rupture is 42,000 psi. For rod and bar stock, tensile is 140,000 psi, bending rupture modulus is 160,000 psi and axial compression strength is 90,000 lb/ sq inch.

SPECIAL PHENOLIC has been developed for receiving permanent metallized or plated coatings. Plastic is a conductor of electricity and resembles metals more than plastics in this respect. Bonding strengths on nickel and copper are 2,000 and 1,500 psi, respectively.

TWO SEALING TAPES composed of polyvinyl-impregnated paper are backed with longitudinal glass fibers. One, claimed to be moisture-proof, is suitable for sealing cans and packages; the other is intended for wrapping coils of wire and banding plate glass, rods and tubing.

METALLIC MATERIALS

A "PINCH" OF ARSENIC in lead alloys used for underground electric cables ups their strength and minimizes cracks caused by expansion and contraction. Heavier than-normal electrical loads can be carried because higher insulating oil pressures are permissible in these 0.001-percent arsenic Sn-Pb and Cu-Pb alloys.

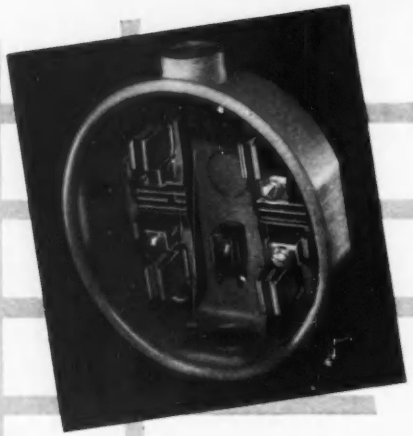
NEITHER COBALT OR COLUMBIUM is used in two special alloy steels applicable to aircraft jet engines and steam turbines. One alloy is stable in the 1,300 to 1,600 F range; the other, containing about one percent nickel, is suitable in range from 1,000 to 1,100 F. No hot or cold working, just normal heat treating is needed.

SOME OF THE NICKEL used in ferrite cores can be replaced by lithium with only slight sacrifice in magnetic properties. Substitution is practical because lithium ions are about same size as nickel ions.

THIN SHEETS of zirconium are being produced commercially by an English firm. Widths vary from 6 to 7 in. and lengths from 2 to 3 ft. Sheets twice as wide will soon be available.

"EMERGENCY" TV SET, reported to perform better than most existing receivers, contains

(continued on page 7)



tooling costs reduced 66⅔%

Let Mr. Ray Blakeman, president of Blakeman Bros. Electric Mfg. Co., Los Angeles, tell you this story of savings with Plaskon Alkyd Molding Compound in the manufacture of his company's commercial and residential watt-hour meter-mounting devices. Mr. Blakeman writes: "Tooling cost is about one-third using this material as compared to the tooling cost of other plastic materials"..."We have found that Plaskon Alkyd lends itself very well to automatic molding, giving us a high production rate on automatic presses"..."Percentage of reworks and breakages is extremely low"..."Our particular device requires a high dielectric strength for which Plaskon Alkyd is noted"..."Since using Alkyd we have not had one operating failure...of our product."

Here is more evidence that parts can be molded better and faster at lower cost—with the amazing quick-curing plastic which has created new concepts of speed and economy in compression molding.

It may pay you well to check the possibilities of Plaskon Alkyd in relation to your product. We will be glad to send you a complete set of the latest bulletins describing the many unusual properties of this unusual thermosetting plastic molding compound.

mold it better and faster with

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PLASKON
ALKYD

no cobalt, and requires only a portion of other strategic materials currently used. These reductions include 68 percent less aluminum, 58 percent silicon steel, 51 percent ferrite, 26 percent copper and 15 percent nickel.

PERFORATED ALUMINUM and Fiberglas TWF wool in the form of a cylinder make an efficient sound-deadening element. Staggered rows of these 7 1/2-ft assemblies suspended on cables in the intake and exhaust ends of test cells absorb most of the noise from large powerplants. Each cylinder has 17 sq ft of acoustical surface.

HALF OF THE TIN normally used in a 40-60 Sn-Pb solder is being replaced with 1.25 percent silver, the difference being made up in lead. During the last war, bismuth played a similar role, but now even bismuth is in short supply.

PROCESSES

INTERRUPTED OIL QUENCHING of carburized gears, king pins and shafts results in improved operation and production economies. This Marquenching setup insures a stress-relieved martensitic structure in parts made of 8620-H, 4620-H, 4815-H and 4820-H. Gears so treated have 100 percent longer service life and 15 to 20 percent higher load carrying capacity.

MIRROR SURFACES are now deposited on non-conducting materials by an induction heating method. Technique is a refinement of the vacuum evaporation procedure. Coating metal is placed in a small crucible surrounded by a metal coil. As coil is heated by induction, the metal evaporates and settles on the non-conductor.

ANOTHER MULTICOLOR FINISH is now on the market. Applied with a standard spray gun from a single pressure container, paint dries to form an over-all textured finish that simulates leather, cork, marble and other materials. Flat, glossy or combination surfaces are obtainable.

IF A MATERIAL is too hard to cut or machine, a vibrating abrasive may be the answer. While ultrasonic energy vibrates a blunt tool at 27,000 cps, a solution of boron carbide particles is directed between tool and stock. Tool hammers the particles against the stock, knocking out bits of material every cycle. Holes and recesses of diameters from 0.007 to 2.0 in. can be formed to tolerances of $\pm$ 0.0002 in. without heating the work piece appreciably.

FLAT SEAMS can be made in sheet steel assemblies by mash resistance welding. Amount of overlap is limited to 1 1/2 times sheet thickness and welding pressure increased to about twice that used in conventional seam welding. In many cases, as-welded joint does not require finishing.

DIE-STAMPED CIRCUITS for electronic equipment are gaining in popularity. Not only are complex conductor networks cut and staked simultaneously, but also components such as shields, inductors, capacitors and switch contacts can be stamped and connected during the one operation.

SYNTHETIC RUBBER O-RINGS can be burnished successfully by putting them in a tumbling barrel along with a few pieces of dry ice. The extremely low temperature produced by the dry ice makes the rings sufficiently hard to be burnished to a satisfactory finish.

COMPONENTS

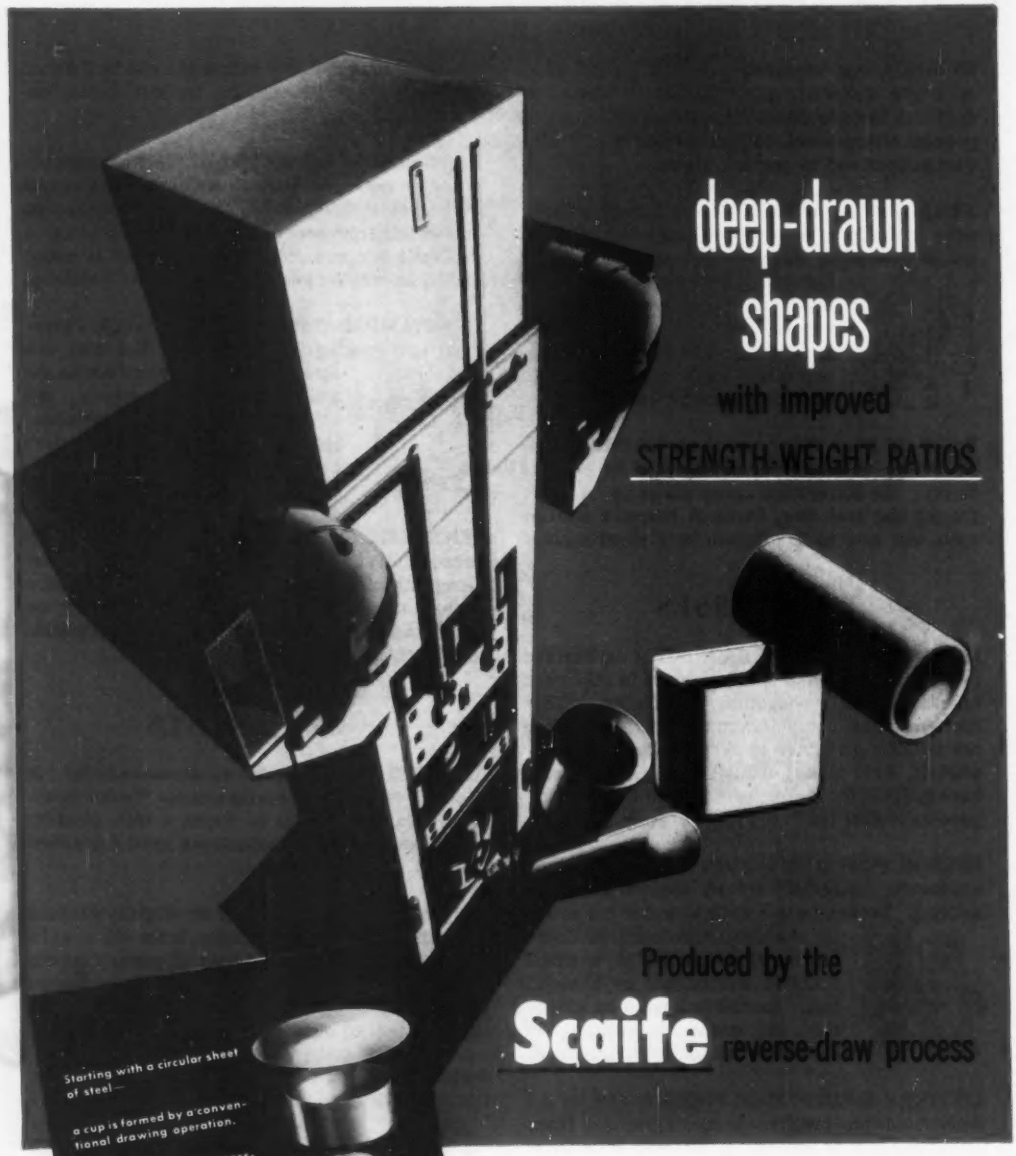
REWIND DEVICE is said to eliminate oscillations in center-wind reroll mechanisms. Usable in all processing equipment in which a web must be tensioned, motor-driven unit can handle finished rolls 44 in. in diameter.

TANTALUM CAPACITOR is but slightly affected by temperature changes ranging from -60 to +175 C--its capacitance drops only 15 percent at the sub-zero limit. Estimated shelf life is five to eight years, a big jump from the 12- to 18-month life of standard electrolytic capacitors.

TEMPERATURE COEFFICIENT of new carbon resistor, developed at Battelle Memorial Institute varies less than 0.1 percent. A special heat resistant paint permits full load operation up to 200 C, a temperature more than double than for other types. Soon to be available commercially, small assembly will see service in television sets and memory devices.

TIMING RELAY can be adjusted for intervals up to three minutes merely by turning a screw at one end. Sealed unit is 3/4 in. in dia and 2 3/8

(continued on page 9)


deep-drawn
shapes
with improved
STRENGTH-WEIGHT RATIOS
Produced by the
Scaife reverse-draw process
Starting with a circular sheet of steel—
a cup is formed by a conventional drawing operation.
A continuation of this pressing operation turns the cup "inside out" without removing it from the dies—
completing—in a single stroke—a deep-drawn shape having remarkably uniform wall thickness.
FOUNDED 1802

Inherent in this process is the ability to maintain uniform wall thickness throughout the entire length of the draw (max. variation within mill tolerance of the material). This means no thin, weak areas, or thick, heavy sections to add unnecessary weight. Physical properties of the metal are improved by the processing.

Scaife deep-drawn shapes can be made in circular and non-circular cross-section. For pressure vessels, containers and tanks of various types, Scaife Reverse-Drawn Shapes provide many advantages. We will be glad to furnish specific information on any items in which you may be interested.

SCAIFE COMPANY

OAKMONT (Pittsburgh District), Pa.

in. long, withstands temperature variations from -70 to +70 C. Single-pole contact assembly is rated at 6 amp; coil for operation at 125 v, a-c or d-c; 4 w power rating.

SEALING WASHERS fill the annulus between a bolt and its hole rim in assemblies such as automobiles. Compressible material conforms to shape of annulus as bolt or screw is tightened sealing out dust, air and moisture. Adherence of the washer to metal surfaces results in an appreciable reduction in the number of squeaks and rattles that develop in equipment that is flexed.

ALUMINUM ALLOY RIVETS in sizes from a half to one inch are available on an experimental basis. Average shear strength reaches 38,000 psi within two weeks after driving and heating range (in air) is relatively wide--850 to 975 F. Probable uses will be in aluminum structures where steel rivets are now standard.

OIL FILTER CARTRIDGE used in air-cooled piston engines retains solids measuring a ten-thousandth of an inch. Filtering elements are made of virgin wool and plastic-impregnated wood cellulose. OD of cartridge is threaded to provide a seal-fit with mating thread in body.

TESTING

ACCURATE MEASUREMENT of capacitor temperature coefficients is possible with special equipment worked out by the Signal Corps. In range from -55 to +85 C, changes in capacitance are measured down to 0.0015 mmf. As many as six samples can be handled at one time.

SMALL HARDNESS TESTER gives accurate readings on flat, curved or round metal shapes as thin as 0.02 in. Depression of steel or diamond point forces liquid in small chamber up into a transparent tube containing a calibrated scale.

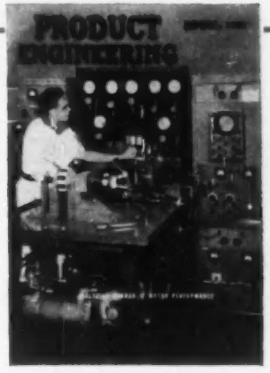
FLASHLIGHT-TYPE STROBOSCOPE is only 1 1/2 in. in diameter and 5 in. long, weighs less than 5 oz. Instrument's small sized eases handling when checking equipment such as motors, timing devices and business machines.

CORROSION PHENOMENA are now being converted to electrical impulses and viewed on an oscilloscope. Cylindrical sample is rotated rapidly in a corrosive solution and scanned with a plastic probe. Eleven silver wires in the probe sense minute electric currents originating in local cells which are the corrosion mechanism.

CONVERTIBLE CAMERA has three removable shutter-lens extension rings that bracket a wide range of focusing distances. With the rings in place, an area measuring 1 1/4 by 1 1/2 in. can be photographed when placed 3 3/4 in. from the lens; without the rings, focal length is two feet.

DIRECT-READING vapor-pressure psychrometer has been developed by the Navy for use in taking humidity measurements where sub-freezing temperatures and precipitation exist. Observations can be from inside a heated room, and humidity read directly in terms of water-vapor pressure without referring to tables.

DIRECT READING resistance thermometer indicates average temperature of liquids over spans of 100 deg to maximum of 500 Fahrenheit.



THIS MONTH'S COVER

Performance specifications on hydraulic transmission equipment are equally as rigid as for pneumatic; electric; or mechanical types—and frequently more so. The set-up shown on this month's cover is typical of tests at Vickers, Inc. to determine the characteristics of hydraulic drives under extremely fast reversal. Transient pressures and performance conditions impossible to determine by observation or field test are calibrated on the electronic oscilloscope. Endurance lasts under full-load conditions; and torque; horsepower, and efficiency at all output speeds and selected operating pressures are additional performance data initially obtained in other laboratory tests.

Ideas you can use!

These diagrams show a few of the ways in which Sylphon bellows assemblies are used—where there's a design problem involving control of temperatures or pressures. They open and close valves, dampers, etc., absorb expansion, provide packless construction, have many more uses.

We've developed bellows assemblies that are used in practically every industry. It's a specialty with us—has been for half-a-century. Skilled craftsmen and complete facilities produce *exactly* what you require, no matter how complex an assembly you need.

Your problem may parallel one we have solved for another customer. Or, we'll work with you to develop an assembly for your specific application—making important savings for you in time, trouble and money.

Wide range of metals and sizes. Write for information. Ask for idea-stirring Catalog GP-1200.

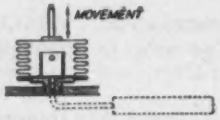


Fig. 1 Thermostatic Motor—This type of assembly is widely used in temperature regulators, etc., where a thermostatic charge is confined in the bellows and where a valve, switch, damper, etc. is to be operated in response to temperature changes.

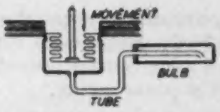


Fig. 2 Thermostatic Motor—This assembly is used where it is desirable to have the thermostatic charge confined outside the bellows and within a cup. May be used with or without remote bulb shown.

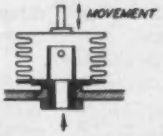


Fig. 3 Pressure Motor—Bellows assemblies are often employed to convert pressure effects into controlled movement. Fig. 3 shows such an assembly where the pressure is applied inside the bellows.

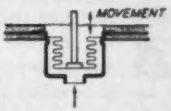


Fig. 4 Pressure Motor—This assembly differs from Fig. 3 in that the pressure is applied outside the bellows and within a cup.

Fig. 5 Expansion Chamber—This type of assembly is employed to absorb thermal or pressure expansion. With suitable heads, it would be used to serve as a reservoir for a liquid or gas. Example: Oil reservoir for electrical cable joint.

Fig. 6 Expansion Joint—Packless and leakless construction for expansion joints used to absorb thermal expansion of pipe lines carrying steam, water, etc. May be used to absorb vibration and provide flexible connection for other applications.

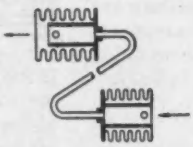


Fig. 7 Motion Transmission—Two bellows assemblies joined by a tube for hydraulic transmission of motion or power. Motive force applied may be either thermostatic or mechanical.

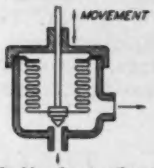


Fig. 8 Packless Construction—Illustrating packless valve construction. Same principle used to seal stem movement or adjustment in many types of apparatus.

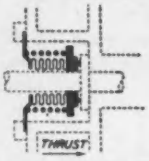


Fig. 9 Shaft Seal—Widely used for refrigeration compressors to prevent leakage around revolving shaft. Spring pressure holds nose of seal against shoulder on shaft. Another type used rotates with shaft and seals against stationary plate.

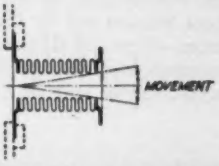


Fig. 10 Flexible Joint—Providing a means to seal a flexible joint or mechanical movement of levers, linkage, etc., against leakage where the movement must be conveyed outside an enclosure. Example: Operating stem of float switches, etc.

TEMPERATURE CONTROLS

FULTON SYLPHON DIVISION
Knoxville 4, Tenn.

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BELLOWS ASSEMBLIES • BELLOWS DEVICES

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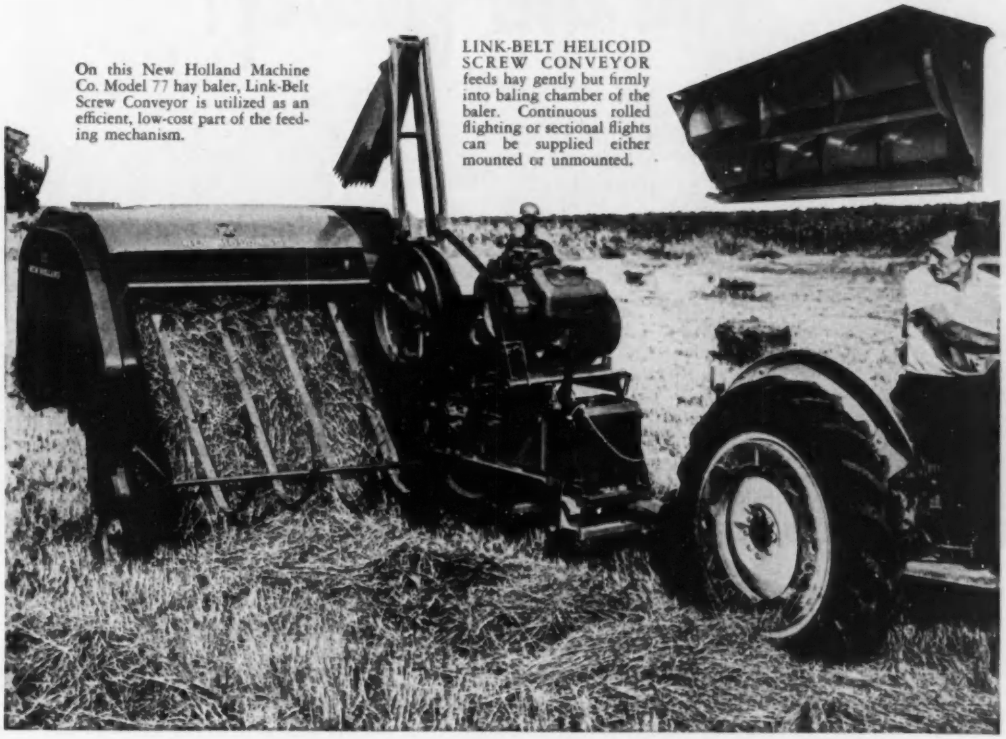
Bridgeport 1, Conn.

All screw conveyors are not the same...

LINK-BELT offers you the *widest range* of types to match your design needs

On this New Holland Machine Co. Model 77 hay baler, Link-Belt Screw Conveyor is utilized as an efficient, low-cost part of the feeding mechanism.

LINK-BELT HELICOID SCREW CONVEYOR feeds hay gently but firmly into baling chamber of the baler. Continuous rolled flighting or sectional flights can be supplied either mounted or unmounted.



MORE than capacity . . . more than length . . . are considered by Link-Belt engineers when they recommend a screw conveyor for your requirements. Abrasiveness, moisture content, size of feed, corrosiveness and many other factors are important.

Remember, Link-Belt is the nation's top producer of materials handling and power transmission equipment . . . another reason why Link-Belt Screw Conveyors are simple, compact, have few wearing parts, greater dependability. Then too . . . they're accurately made to insure easy assembly and smooth operation.

And you'll find versatile screw conveyors efficiently handling other jobs — elevating, conveying, digging, mixing, spreading, and feeding applications. Get the complete story from the Link-Belt office near you.

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How about finishing?

Magnesium can be finished easily, economically and with satisfactory results. The procedures used are much the same as those employed with other metals. After thorough cleaning, a chemical finish is applied and this is followed by the desired paint coatings. Important considerations are the proper choice of chemical treatment and paint materials.

Dow has exposed thousands of test panels under various conditions to determine the best paint materials and the most efficient complete paint systems. As a result, paint systems are available which meet normal requirements and combine adequate protection with attractive decorative characteristics. Detailed recommendations are available for conditions under which magnesium is used in service ranging from baked enamel systems for office machines to weather resisting air dry primer and finish combinations for truck bodies and trailers.

For complete information on finishing methods call your nearest Dow sales office or write direct.

Magnesium Division, Dept. MG-64

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MIDLAND, MICHIGAN

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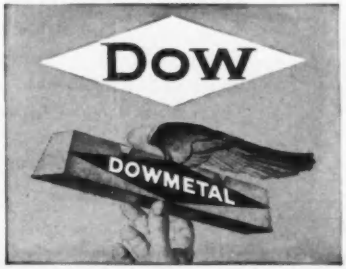
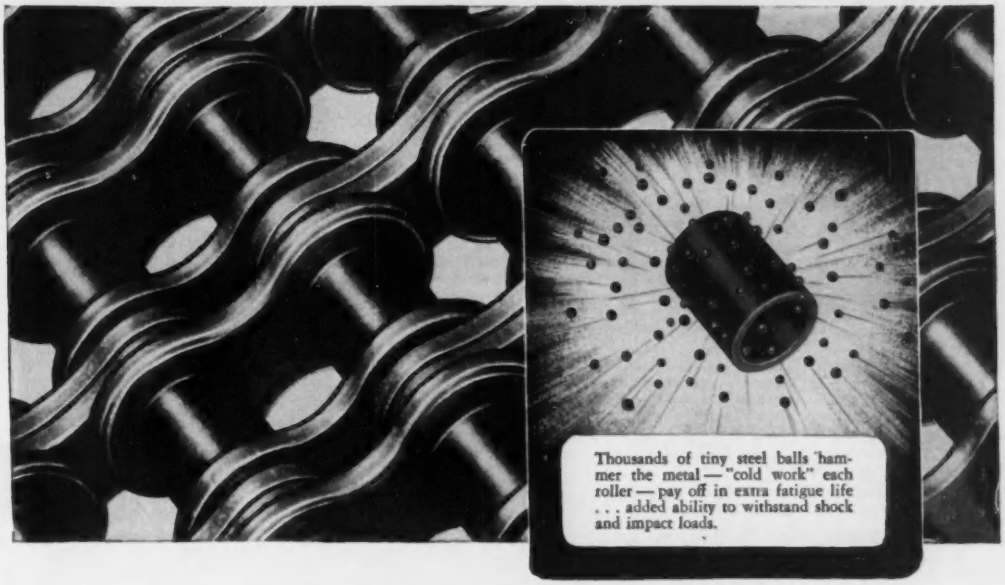



Thousands of tiny steel balls hammer the metal — "cold work" each roller — pay off in extra fatigue life . . . added ability to withstand shock and impact loads.

Why you should be sure the roller chain you buy has

SHOT-PEENED ROLLERS

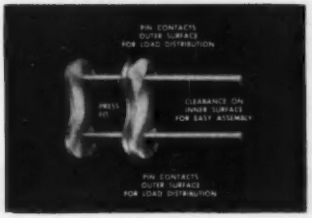
. . . one of the extra-strength features you get with every LINK-BELT Roller Chain

Look for the distinguishing darkened rollers on every roller chain you buy! They're your guarantee of extra fatigue life.

Shot-peening is just one of the added manufacturing refinements that make Link-Belt Precision Steel Roller Chain a longer-life chain. Controlled material selection and heat treating assure absolute uniformity . . . no weak members.

Link-Belt Roller Chain is available in single or multiple widths, in ⅜ to 3 in. single and double pitch. For the best in roller chain, get in touch with your nearest Link-Belt office.

Easier coupling and uncoupling without sacrificing load distribution


PIN CONTACTS OUTER SURFACE FOR LOAD DISTRIBUTION
PRESS FIT
CLEARANCE ON INNER SURFACE FOR EASY ASSEMBLY
PIN CONTACTS OUTER SURFACE FOR LOAD DISTRIBUTION

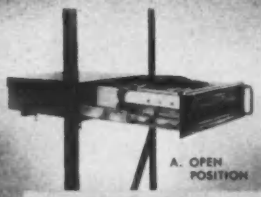
Patented E-Z Assembly feature of Link-Belt Precision Steel Roller Chain has won world-wide approval. Coupling and uncoupling of multiple width chains—right on the job—is far easier. There's absolutely no sacrifice of load distribution . . . no loss of the chain's remarkable performance. Press-fits between chain pins and middle bars have been modified. But full load-carrying capacity across the entire width of the chain has been maintained.

LINK-BELT

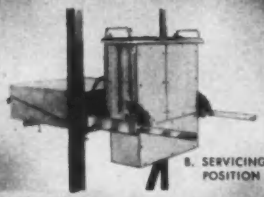
PRECISION STEEL ROLLER CHAIN

LINK-BELT COMPANY: Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in principal cities. 12.333

ELECTRONIC SLIDES



A. OPEN POSITION



B. SERVICING POSITION

A. Featuring Smooth continuous action. Closely fitted slide parts assure minimum of play. Locking device holds slide when fully extended, permitting easy access to all parts.

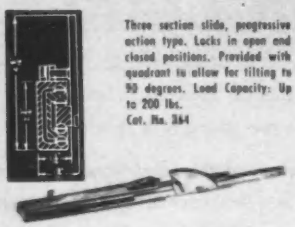
B. Quadrant for pivot support and tilting provision is equipped with simple tripping mechanism for servicing. Lever operated, it releases chassis and allows movement to open and closed positions.

Illustration shows an Automatic Transmission Measuring Set as developed by Bell Telephone Laboratories at Murray Hill, New Jersey.

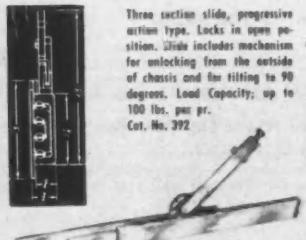
The receiving amplifier, modulator, amplifier modulator and recorder panels are suspended on *ball-bearing drawer slides* and are pivoted to permit the chassis to be inverted for servicing. The arrangement is such that all these panels can be kept in operation while so inverted.

Three section slide, progressive action type. Locks in extended position only. Tripping mechanism controls unlocking. Load capacity: Up to 200 lbs.
Cat. No. 375

Three section slide, progressive action type. Load Capacity: Up to 50 lbs. per pair.
Cat. No. 350



Three section slide, progressive action type. Locks in open and closed positions. Provided with quadrant to allow for tilting to 90 degrees. Load Capacity: Up to 200 lbs.
Cat. No. 384



Three section slide, progressive action type. Locks in open position. Slide includes mechanism for unlocking from the outside of chassis and for tilting to 90 degrees. Load Capacity: up to 100 lbs. per pr.
Cat. No. 392

Three section slide, progressive action type. Locks in extended position only. Thumb release controls unlocking. Load Capacity. Up to 200 lbs. maximum.
Cat. No. 371

The present preparedness program requires that manufacturers be absolutely certain of the precision and dependability of all component parts. Over 50 years of dependability lie behind Grant Pulley & Hardware Co. Our extensive engineering and research department is constantly planning new and improved sliding devices. This department is available for consultation on individual specifications, and also provides engineering liaison from inception to conclusion of production. Chassis, Consoles, Racks, any device where access to parts or motion of equipment is desired should be equipped with Grant Slides. Wherever the installation, laboratory, tank, bomber, ship, mobile or stationary unit . . . you save time and manpower when you use Grant Sliding Devices.

Grant Slides are adaptable for many military uses, and Grant customers with Government contracts can rely upon the dependability of Grant cooperation and delivery.

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GRANT PULLEY & HARDWARE CO.

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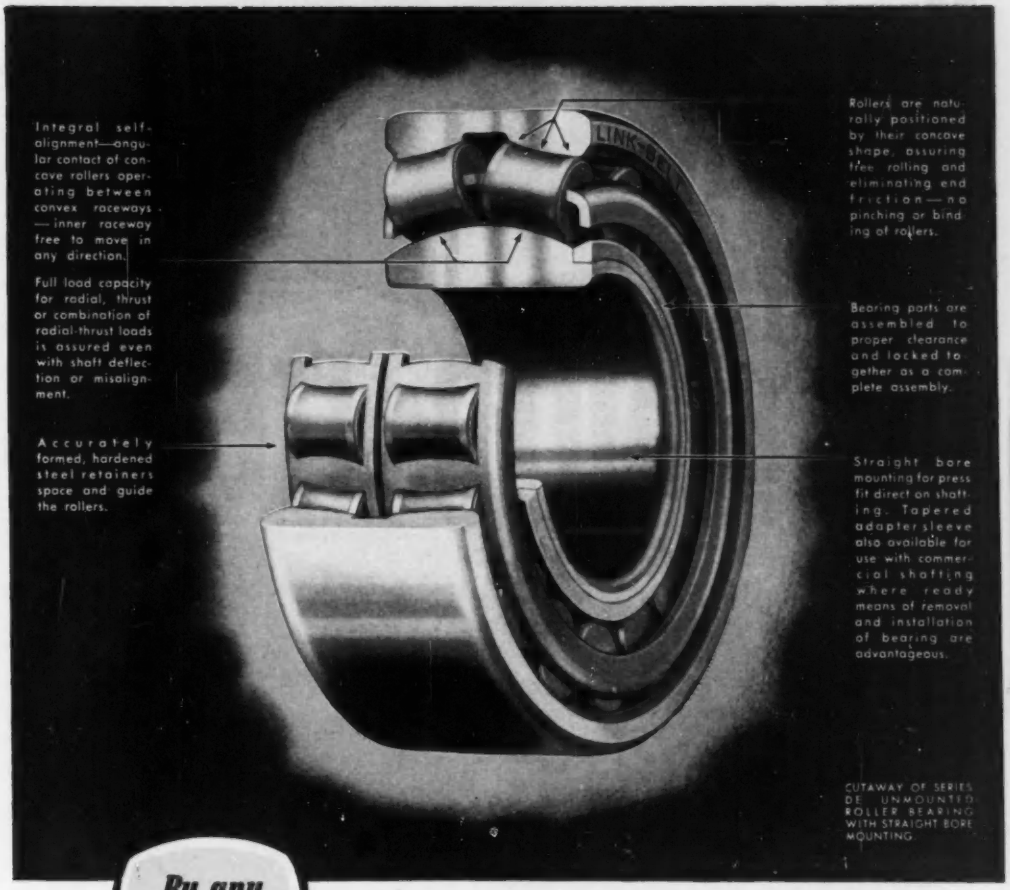
LINK-BELT Ball and Roller Bearings smooth the path of power


Integral self-alignment—angular contact of concave rollers operating between convex raceways—inner raceway free to move in any direction.
Full load capacity for radial, thrust or combination of radial-thrust loads is assured even with shaft deflection or misalignment.
Accurately formed, hardened steel retainers space and guide the rollers.
Rollers are naturally positioned by their concave shape, assuring free rolling and eliminating end friction—no pinching or binding of rollers.
Bearing parts are assembled to proper clearance and locked together as a complete assembly.
Straight bore mounting for press fit direct on shafting. Tapered adapter sleeve also available for use with commercial shafting where ready means of removal and installation of bearing are advantageous.
CUTAWAY OF SERIES DE UNMOUNTED ROLLER BEARING WITH STRAIGHT BORE MOUNTING.

By any standard . . . LINK-BELT Roller Bearings always assure anti-friction alignment

Integral self-alignment of Link-Belt Unmounted Roller Bearings eliminates need for expensive, cumbersome self-aligning housings. Angular contact, concave rollers between convex raceways, provides capacity for thrust and radial loading. Preadjusted for clearance at the factory and packed to reach you in "final inspection" condition, they require no adjustment when you're ready for installation. There's a Link-Belt Bearing Specialist near you who can give you expert advice on *any* bearing application. You can also get all the facts from Data Book 2550.

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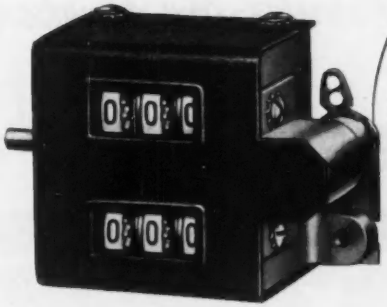

"Round and round and round they go—and what they count: only radarmen know!"

Everyone Can Count on VEEDER-ROOT

Yes, this time as before, every arm of the service counts on Veeder-Root in some way or other. The counters shown, for instance, supply figures that radarmen readily translate into vital information.

And there are scores of other Veeder-Root Counters, standard and special, electrical and mechanical, that "talk the language" of more military and civilian jobs than you can shake a slide-rule at!

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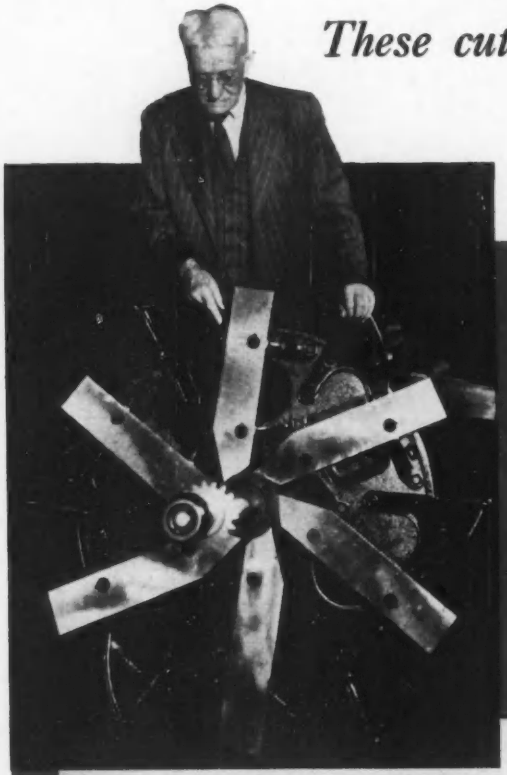
VEEDER-ROOT COUNTERS "Count Everything on Earth"

Now made of U·S·S

These cutter blades are tougher,



W. H. Preston, President of Papec Machine Company, examines the sharp edge on one of the six blades mounted on the cutting wheel of a Papec machine.

Because of the uniformity of CARILLOY 4150 blades, grinding of the beveled edges can be done with a multiple set-up on this Hanchett grinder.

Stones, wood, roots and even bits of metal pass through the spinning blades of Papec forage harvesters. Now made from heat-treated CARILLOY 4130, these blades are tougher than ever — and easier and cheaper to fabricate.

Carilloy Steel...

harder—yet easier to fabricate

and cost 25% less!

SOMETIMES it costs less to use steel that costs more. Here's a case history to prove it.

Ensilage cutters and forage harvesters made by Papec Machine Company have long been regarded as tops in agricultural circles. The working heart of these machines are the cutter blades—and they really take a beating. When handling crops from stony fields, appalling amounts of stone along with wood, roots and bits of metal pass through the blades. To withstand abuse like this the blades *have* to be very tough indeed.

Papec formerly used a "laid-on" blade—a low carbon steel body with a high carbon cutting edge rolled on under high pressure and heat. These blades were good—but Papec wanted to make them better. So they called in our service metallurgist. Working closely with their engineers he finally found a way to greatly increase cutter blade durability. Now these vital parts are made of extra-tough, extra-hard *alloy* steel —heat-treated U·S·S CARILLOY 4150.

Simplified fabrication with U·S·S Carilloy 4150 cuts cost 25%

CARILLOY 4150 is plenty tough inside. Therefore it can safely take shocks that would ruin a more brittle blade. But it's also extremely hard on the surface—to furnish a sharp cutting edge that *stays* sharp. In other words, U·S·S CARILLOY 4150 provides the ideal combination of toughness and hardness that prevents damaged blades and time-wasting shutdowns.

In this application, CARILLOY 4150 does more than make a better blade—it speeds up fabrication, too. Testing it against air-hardening tool steel, Papec engineers found that, after heat-treating, CARILLOY 4150 showed all-round better characteristics and held a keen edge longer. The steel was also much more *uniform*. This uniformity paid off in two ways: First, the heat-treated CARILLOY blades were *easier* to machine. Second, the blades were less distorted after heat treatment, so *less* machining was required. As a result, the CARILLOY blades not only were much cheaper than air-hardened tool steel, but actually cost 25% less than the old "laid-on" blades.

Whatever properties your product needs—strength, toughness, light-weight, or superior durability under trying conditions — service-tested U·S·S CARILLOY Steels can provide them. And quite often at lower cost.

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UNITED STATES STEEL

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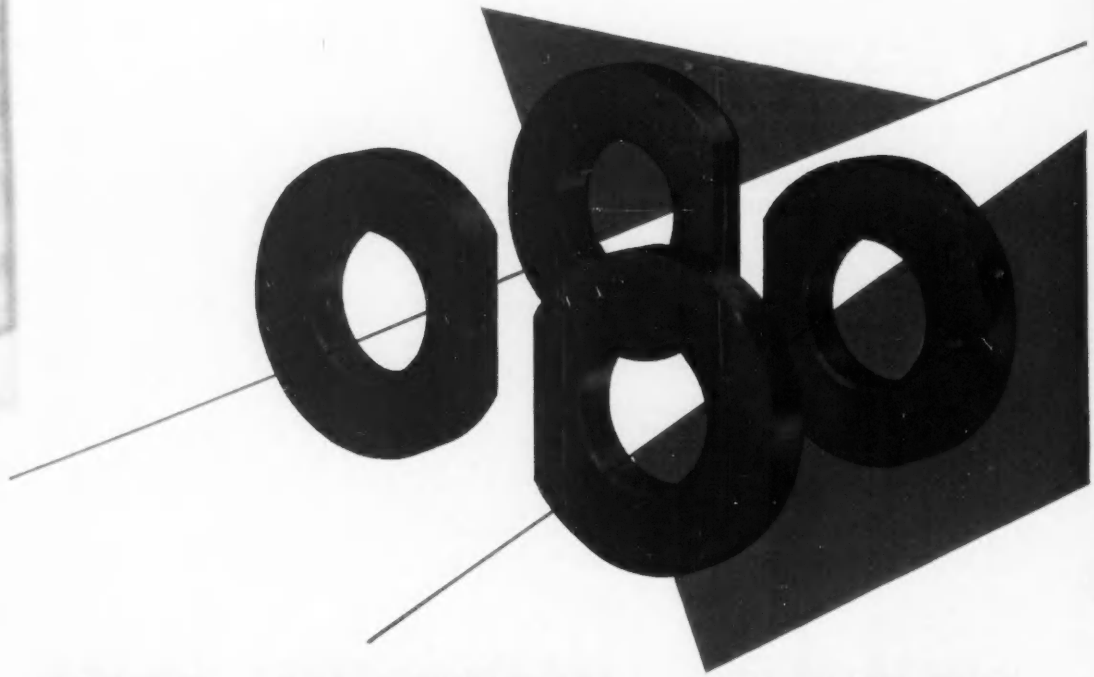
TINY ROMEC PNEUMATIC MOTOR EQUIPPED WITH GRAPHITAR THRUST PLATES INSURES INSTANT AND POSITIVE OPENING OF NAVY FIGHTER CANOPY IN EMERGENCY

With the aid of GRAPHITAR parts, the Romec Division, located in Elyria, Ohio — a division of Lear, Inc., of Grand Rapids, Michigan, is now manufacturing one of the neatest, most efficient little compressed air motors you ever saw. It's about the same size as pictured here, and it performs — in a pinch — about as vital a task as there is. For it is this little motor that transmits the power to force open the plexiglas canopy of jet planes when the pilot wants to get out in a hurry. The power is supplied from a small 1000 psi air bottle. The motor is the rotary gear type. At each end of each rotor are the GRAPHITAR thrust plates. Like all GRAPHITAR parts, these thrust plates are perfect for the job because they are unaffected by high speeds, wear, pressure or extreme temperatures. They cannot corrode, even when exposed to attack by concentrated acids (as is the case in some installations).



THE UNITED STATES

pilots out of a jam!

GRAPHITAR is an extremely versatile engineering material that is ideal for seals, bearings, cylinder liners, pistons and many other parts. GRAPHITAR saves weight, improves product performance and makes important savings in critical metals such as steel and aluminum . . . metals that can be diverted for defense weapon production. GRAPHITAR parts can be produced in any practical size and shape to tolerances as close as .0005". Let us see if GRAPHITAR can improve the efficiency of your products. Write today to:

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GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

Designer's NOW up to 200 hp in one compact package!

New G-E Speed Variator power "package," typical of ratings 75 to 200 hp, comes in two units for greater plant-layout flexibility. M-g set cabinet (5 ft ⅛ in. high by 9 ft 9½ in. wide by 3 ft 4 in. deep) may be located away from or bolted to control cabinet (7 ft 6 in. high by 2 ft 6 in. wide by 3 ft 4 in. deep).

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All the advantages designers have appreciated in General Electric Speed Variators—packaged, pre-engineered adjustable-speed drives operating from a-c power systems—can now be obtained in units rated 75 to 200 hp. On punch presses, wire drawing machines, mill auxiliary drives, etc., they provide the same speed ranges up to 40:1 and beyond, good speed regulation, great operating flexibility, and minimum installation and maintenance cost.

GENERAL ELECTRIC *Headquarters for* Electric ADJUSTABLE-SPEED DRIVES

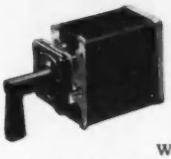
With adjustable-voltage control in whatever type is most suited to the need—straight magnetic, amplidyne, or electronic—this new drive requires no special foundations, includes all necessary protective features, and contains all wiring between components except to the remotely-mounted motor and operator's controls.

Best of all, standardized component design lets you specify only the features you need, permits prices comparable to other drives that require costly field assembly. For more information on these new larger-hp Speed Variators, check your nearest G-E Apparatus Sales Office. Bulletin GEA-5335 describes Speed Variators in 1–60 hp ratings.

GENERAL ELECTRIC

Digest

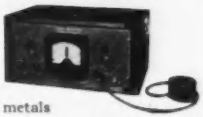
PRODUCT HIGHLIGHTS



VERSATILE SWITCH makes good 10,000 ways!

What's behind the success story of the General Electric Type SB-1 switch? Simply this: By varying its many *standard, interchangeable* cams, contacts, fingers and other parts, you can arrange for over 10,000 control and transfer combinations, use it for practically any control job on low-capacity circuits. For extra-heavy duty, there's the tougher Type SB-9, with the same features plus extra wear-resistance. Both types mount on ⅛- to 2-inch-thick panels, are rated up to 20 amperes at 600 volts a-c or d-c. See Bulletins GEA-4746 (SB-1) and GEA-4114 (SB-9).

METALS COMPARATOR cuts scrap losses economically!



With both ferrous and non-ferrous metals now in tight supply, you'll need the material savings a General Electric metals comparator can bring you. It provides an economical, non-destructive test of metal parts for composition, heat treatment, hardness, or plating thickness—decreases scrap losses due to mixed material or incorrect processing. Parts are quickly compared against a reference standard. Uses single-phase, 60-cycle, 110-volt supply. See Bulletin GEC-566.

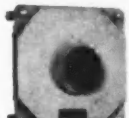
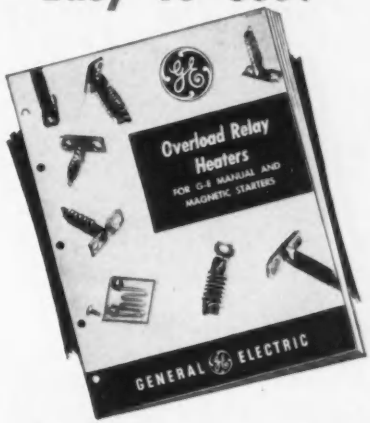


PLATE-TYPE RHEOSTAT gives accurate speed control!

Specify these General Electric plate-type field rheostats for mounting on a machine tool, switchboard, or control or operator's panel, and you've provided for speed control of d-c motors, or voltage control of generators and exciters. The 6-, 9-, and 12-inch standard sizes contain 27, 52, and 70 resistance steps for accurate adjustment. Adjustable stops at each end of travel save time, assure uniform operation, are easily reset for added flexibility. See Bulletin GEC-487.

New! Complete! Easy to use!



LISTS RELAY-HEATER RATINGS FOR G-E MOTOR STARTERS

Just out is this handy guide to the selection of overload relay heaters for most types and sizes of General Electric manual and magnetic starters. In one convenient 16-page reference booklet, it concentrates data from many sources, makes it easier and faster for you to match heaters to motors. Check Bulletin GEC-127B in the coupon below.

General Electric Company, Sec. C 668-88
Schenectady 5, New York

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- ☐ GEA-4746 Type SB-1 switch
- ☐ GEA-5335 1-60 hp speed variator
- ☐ GEC-127 Relay-heater catalog
- ☐ GEC-487 Plate-type field rheostat
- ☐ GEC-566 Metals comparator

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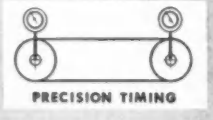
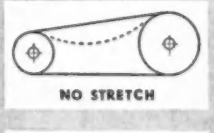
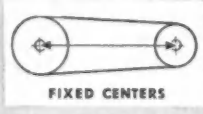
ALL GRIP...

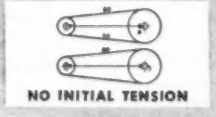
LOW OR HIGH SPEEDS


PRECISION TIMING


NO STRETCH

LARGE RATIOS POSSIBLE


FIXED CENTERS


NO INITIAL TENSION

SMALL PULLEY DIAMETERS

Gilmer "Timing Belt" patented 1950

...NO SLIP!

Gilmer "TIMING BELT"* DRIVE

...revolutionary tooth-grip belt solves countless problems in power drive design

The newest idea in belt drives—and already thousands are in use! A strong, tooth-grip belt that makes positive engagement with axial-grooved pulleys. With the Gilmer "Timing Belt" Drive, there's no slip, creep, or stretch, no speed variation. Just sure, dependable PULL! Where constant starts and stops are a factor, this drive reduces inertia!

And it's powerful, *precision* pull! Steel-cable pulling elements give enormous tensile strength—eliminate stretch . . . Cables are embedded in a body of tough, oil- and heat-resistant Neoprene for sturdy, long-lasting service. And, because speeds of driver and driven pulleys synchronize perfectly, rpm's are always uniform, always controlled!

Get the complete story: Write for illustrated brochure which describes features of the Gilmer "Timing Belt"; shows how design engineers of some of the leading companies use it to improve the performance of their machines; gives valuable suggestions for drive designing.

**Reg. Trade Mark.*

✓ FOR SYNCHRONIZING DRIVES!

✓ FOR POWER TRANSMISSION!

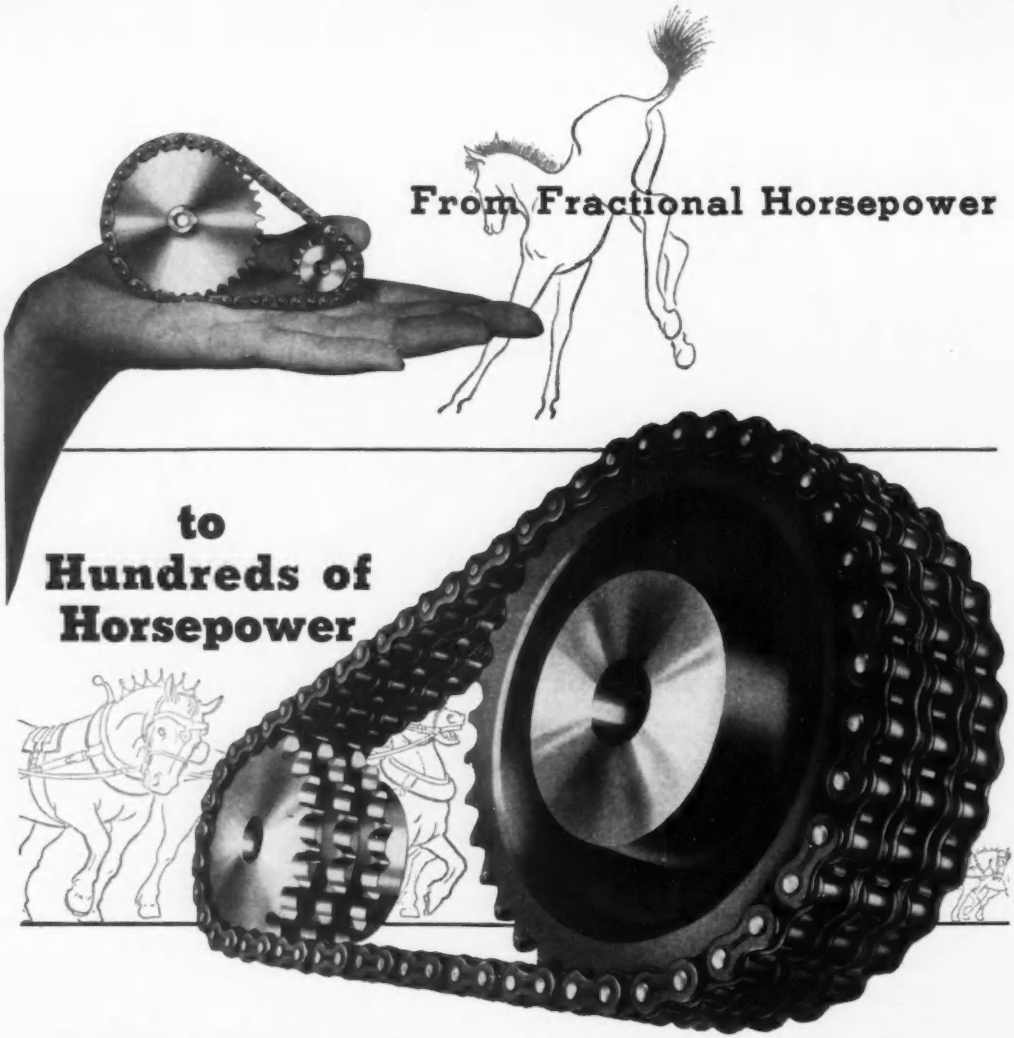
✓ FOR FUNCTIONAL OPERATIONS!

Gilmer BELTS

L. H. GILMER COMPANY

410 Tacony, Philadelphia 35, Pa.

Division of United States Rubber Company



Whitney Chain Drives Simplify Design—Cut Costs

No matter what your drive problem, be it small movie cameras, machine tools or earth movers, you will find a Whitney Chain Drive to fill the application exactly.

And what's more, these adaptable drives offer opportunities for important cost reductions and improved performance. *For example* — Whitney Chain Drives operate equally well on long or short centers. They will drive single or multiple shafts, provide accurate timing or reversal of direction. Standard attachments, built into the chain, offer still more opportunities for economical application possibilities.

And remember, Whitney Chains . . . *the all-steel drives* . . . deliver *full rated* power, smoothly and dependably. Their positive grip transmits constant, uniform speed. They are easily and quickly installed, reducing costly down time. No removal of shafts or bearings necessary. Alloy steel construction assures maximum service with minimum maintenance.

WHITNEY ENGINEERING SERVICE — In addition to the service facilities of more than 130 Distributors, Whitney maintains a network of 15 Field Engineering Offices, located throughout the country. From the complete line of Roller, Silent and Conveyor chains, Whitney engineers can recommend the proper type of drive for your application . . . the chain drive which will give you the best service at lowest cost. Consult your nearest Whitney field office or write us direct for catalog and complete information.

WHITNEY CHAIN COMPANY

204 Hamilton Street, Hartford 2, Connecticut

purchasing agents know...

there's no guess when it's a finish by...

STANDARD

Linked to Industry.

STANDARD VARNISH WORKS

Makers of Fine Finishes Since 1870

NEW YORK LINDEN, N. J. CHICAGO

Simplifies installation in cramped quarters. The smaller size of Life-Line motors aided designers of machines and equipment . . . required less space. Pre-lubricated bearings eliminated extra fittings and piping.

Compact design minimizes required space. Life-Line starters installed in control cabinet on a precision lathe. Front removable parts and straight-through wiring saved additional space . . . facilitated general servicing.

Cramped?

Here's how to stretch space

Life-Line motors and Life-Linestarters® are space stretchers. The reason? "Compactness." They are smaller, lighter than most conventional types . . . often can be installed in close quarters where others cannot be accommodated.

Take the case of this grinder manufacturer, for example: The motor is mounted under the bed inside the housing. Space is at a premium. With ordinary conventional motors, it was necessary to grind part of the motor housing away so that motors could be squeezed into the available space. Life-Lines (as much as ⅓ smaller for the same frame size)—fit with room to spare.

Further, the pre-lubricated, sealed bearings eliminate the need for bringing grease fittings to the outside of the housing. This means an additional saving of several dollars per machine—in materials and labor.

Life-Linestarters match the motors for compactness. Because all parts can be removed straight from the front, there is no need to allow extra workroom for servicing. Further, straight-through wiring means simplified wiring, shorter leads, less space. You can have two electrical interlocks without increasing Life-Linestarter width. After that, two more may be added with little additional space.

These space savings result in smaller cavities . . . and more compact cabinets . . . reducing your costs. NEMA mountings are standard for the complete line.

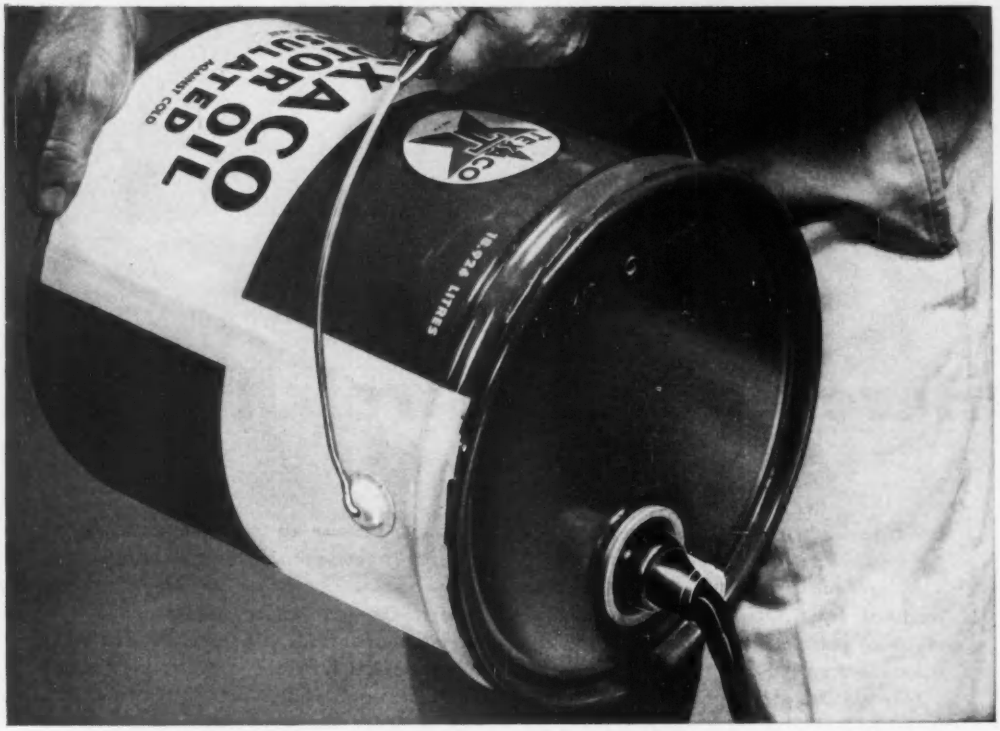
More data? Complete information, on sizes and mounting dimensions, is available from your nearby Westinghouse representative. Ask him for copies of "Life-Line Motor Book", B-3842 and "Tomorrow's Starter Today", B-4677 or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21625

YOU CAN BE SURE . . IF IT'S

Westinghouse

Life-Line

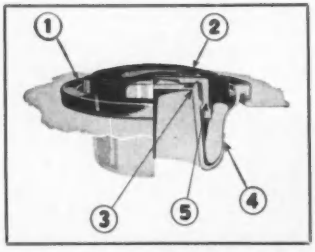
MOTORS and CONTROLS



SEALS WITHOUT SEEPAGE...POURS WITHOUT SPLASH

The Texas Company uses new pouring spout-closure made with Du Pont "Alathon" to fill need of 18 years' standing

For 18 years or more, The Texas Company reports, shippers have needed a closure for pails that would seal without evaporation and leakage. Now, with the new "FlexSpout"* closure, which they use in shipping automotive and industrial lubricants, Texaco has the solution to this problem. Moreover, they can offer their customers an easier, more efficient method of pouring.



CUTAWAY shows how "FlexSpout" protects contents. (1) Metal rim clamps gasket directly to pail, (2) tamperproof metal seal is destroyed at first removal, (3) hermetic seal molded as part of spout provides added protection against leakage, tampering, (4) continuous retractable spout and diaphragm molded of "Alathon" makes leakproof seal, lets contents drain without ever touching outside of spout, (5) cap of "Alathon" for re-use after seals are broken.

The spout-closure, is made with Du Pont "Alathon"† polythene resin. Before adopting it, Texaco put it through a series of tests exaggerating actual shipping hazards—rough treatment, humidity, etc. Result: no sign of losses through evaporation or leakage. Texaco now uses "FlexSpout" for all domestic and export shipping.

The unusual combination of properties found in "Alathon" fits the "FlexSpout" to a "T." Its flexibility is made to order for the retractable spout design —as is its extreme toughness. Its resilience allows a crimped, leakproof seal, which will withstand the pressures that might build up in the container during shipment. "Alathon" has excellent chemical resistance, is tasteless, odorless, non-toxic, and so cannot contaminate or otherwise harm the contents.

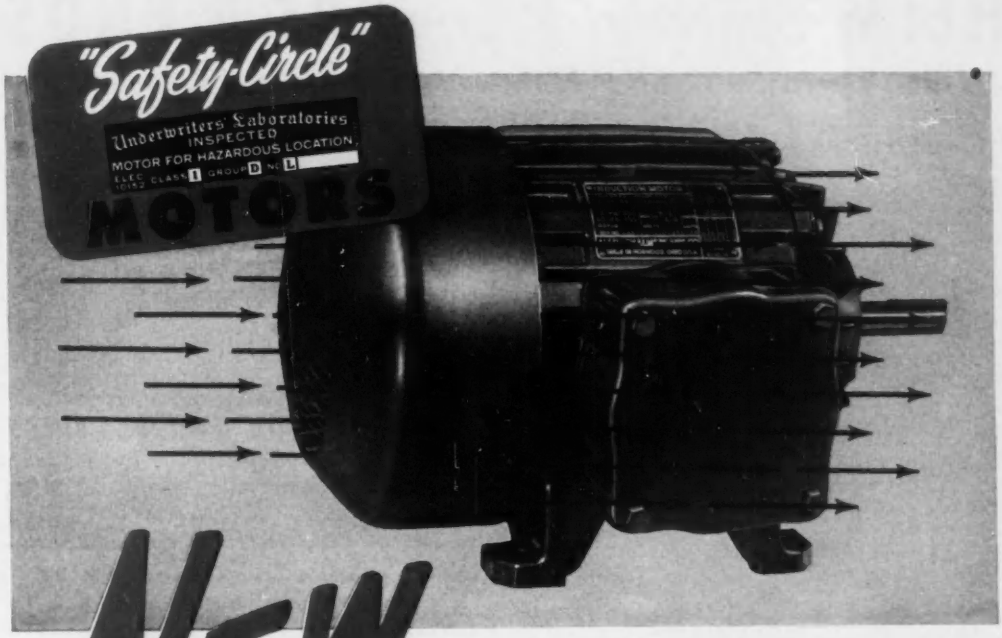
Along with its use for closures and a variety of other forms of packaging, "Alathon" is finding many applications in a wide range of industries. It may well be of service to you. Demand for "Alathon" currently exceeds supply. However, we suggest you investigate its properties, and prepare for future applications. We'll gladly discuss the availability of quantities for development work. For information, write:

E. I. du Pont de Nemours & Co. (Inc.)
Polychemicals Dept., District Offices:
350 Fifth Avenue, New York 1, N. Y.
7 S. Dearborn St., Chicago 3, Ill.
845 E. 60th St., Los Angeles 1, Calif.

*"*FlexSpout*" made by Rieke Metal Products, Auburn, Indiana*

†TRADE-MARK

DU PONT
REG. U. S. PAT. OFF.
PLASTICS
Better Things for Better Living
. . . through Chemistry



NEW Easy to Clean Resists Corrosion

HERE IS A NEW EXPLOSION-PROOF MOTOR that will solve many of your design problems. You can place it anywhere you please because it almost never needs cleaning or routine maintenance. There are no corners, pockets or hidden air passages to collect dirt. Fan and housing design keep cooling air flow tight against the yoke so dirt does not accumulate. When cleaning is required, simply blow the dirt off the outside of the motor with an air hose.

Pre-lubricated Bearings

Bearings are pre-lubricated at the factory and should need no attention for years. Extra rigidity of the cast iron frame holds bearings in alignment under all operating conditions.

Corrosion Resistant

Major external parts are of cast-iron with consequent inherent corrosion resistance of this familiar metal. No extra treatment is required and cast-iron's corrosion resistance won't chip off.

Get All The Facts

The new *Safety Circle* Type APZZ explosion-proof motor is built in Nema standard frame sizes from 224* to 505. Call your nearest Allis-Chalmers Authorized Dealer or Sales Office or write Allis-Chalmers, Milwaukee 1, Wisconsin for Bulletin 51B6144. A-3342

Sold . . .
Applied . . .
Serviced . . .

by Allis-Chalmers Authorized Dealers, Certified Service Shops and Sales Offices throughout the country.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

TEXROPE — Belts in all sizes and sections, standard and *Vari-Pitch* sheaves, speed changers.

PUMPS — Integral motor and coupled types from ¾ in. to 72 in. discharge and up.

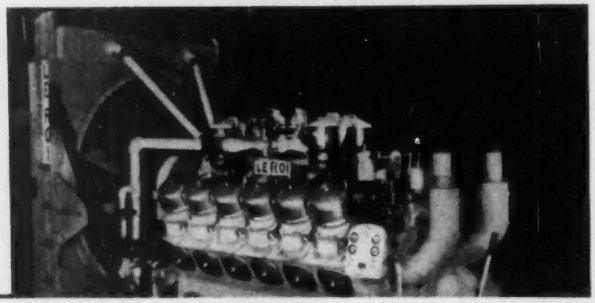
Safety Circle, Texrope and *Vari-Pitch* are Allis-Chalmers trademarks.

ALLIS-CHALMERS

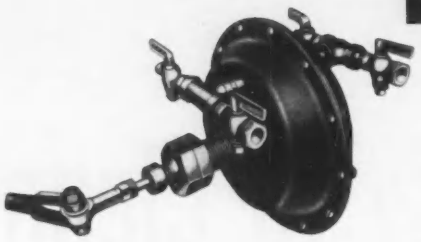
*Similar design non-ventilated motors, Type APKK, also available in frames 203 to 224 inclusive.

HEIM *Spherical Bearing* ROD ENDS

are used wherever motion is to be transmitted at odd and varying angles.



Here is a typical application of **HEIM ROD END BEARINGS**
on the giant Le Roi 600 h.p. L-3460 engine for tough pipe line power applications.



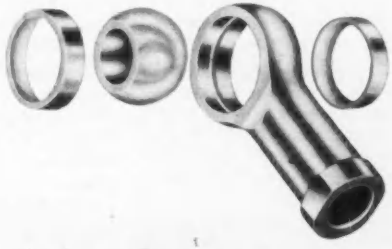
When two or more engines are operated as a unit, the Gemsco Syncontrol is the vacuum synchronizer which efficiently synchronizes multi-engine installations. Here again is illustrated the application of the Heim Spherical Bearing Rod End to an instrument extremely sensitive in its response to the slightest change in manifold pressures.

These applications are shown through the courtesy of the General Machine & Supply Company of Odessa, Texas.

The **HEIM SPHERICAL BEARING** *embodies a simple but revolutionary principle.*

A single ball revolves in spherical bronze bearing inserts which are shaped around the ball and expanded into interlocking relationship with the outer member to form the complete rod end or bearing unit.

To illustrate this construction, we show here an exploded view of this single ball principle – the longer lasting, more efficient HEIM Spherical Bearing.



Whether your linkage mechanism is on delicate, small parts, or on heavy, giant machinery, you will find a HEIM Spherical Bearing Rod End to meet your requirements, for they are available from stock in sizes from 1/8" to 1" bore, or made to order in larger sizes.

Please write for catalog or any special engineering data to

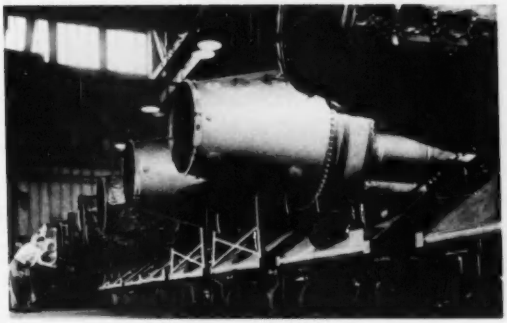
THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

FRED A. HOFMANN, production vice president of the Elastic Stop Nut Corporation of America, says, "We're back on a full 2-shift production schedule, and practically every one of the 62 Tri-Clad motors we've installed since 1941 in our plant at Union, N. J., is going night and day. Sure, we make a lot of steel products, but for a general-purpose motor, we don't think you can beat cast iron. After the pounding we've given our Tri-Clad motors for the past 10 years, we're stronger than ever for Tri-Clads."

ELASTIC STOP NUT CORPORATION:

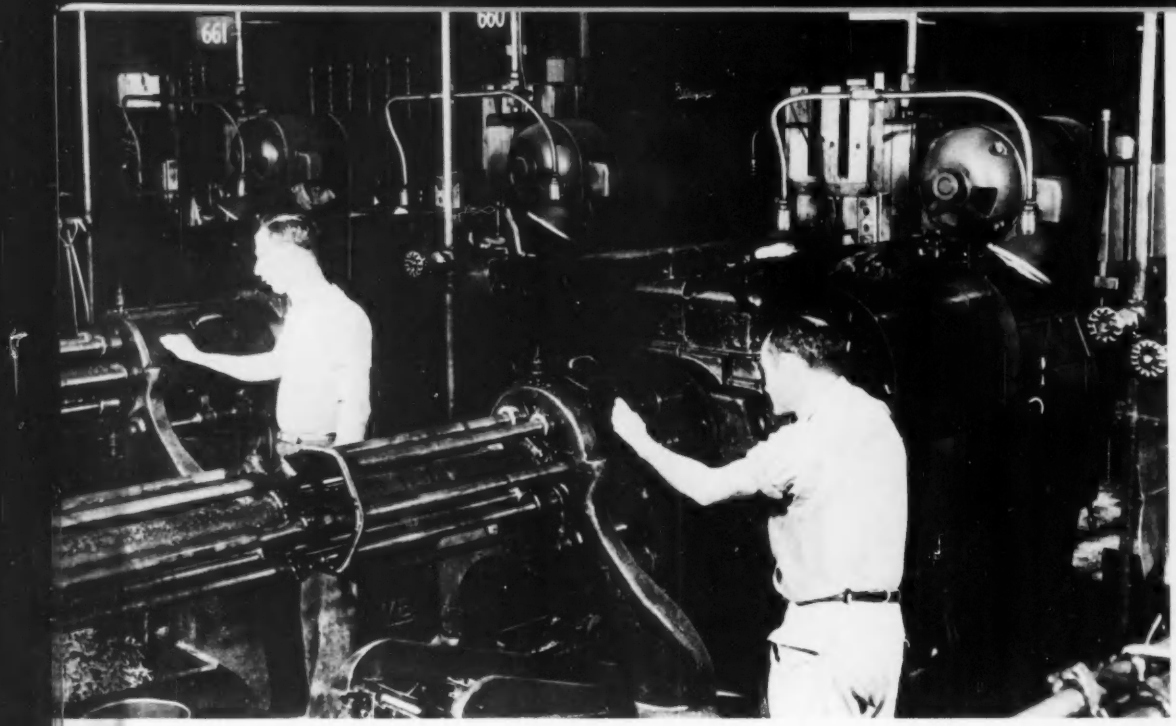
"We're stronger than ever for Tri-Clad triple protection!"



TRI-CLAD MOTORS drive machines that produce ESNA fasteners for use on jet aircraft engines—the engines that power our modern military planes. Each of the jet engines above uses a large number of these special stainless-steel high-temperature nuts, designed to hold under the extreme heat and other severe conditions of jet-engine operation. Moreover, these nuts must be re-usable without seizing or galling the finish. ESNA counts on the reliability of their Tri-Clads to help turn out thousands of these fasteners every day.

VIRILE VETERAN. This 10-hp Tri-Clad motor has been driving an Acme Gridley multiple spindle bar machine for nearly 10 years. It's still going strong, another reason why, after 10 years, ESNA thinks Tri-Clad is still their best motor buy! And today's Tri-Clad motor, all-industry favorite, is better than ever!

GENERAL ELECTRIC



4 STEPS—AND NO HANDS! Backbone of the ESNA production line, the Acme Gridley automatic bar machine (3 shown above) ejects a finished nut blank every 4½ seconds. The operator simply keeps the six spindles supplied with bar stock. The machine feeds stock, machines the nut profile, drills 2 holes and cuts off to accurate lengths. The load on the 10-hp drive motor is heavy and constant—but Tri-Clad, with its bearings completely enclosed in cast-iron housings, can take it! Maintenance department can't recall a single Tri-Clad bearing ever having to be replaced. Moreover, if they need it, the motors are easily greased while running.

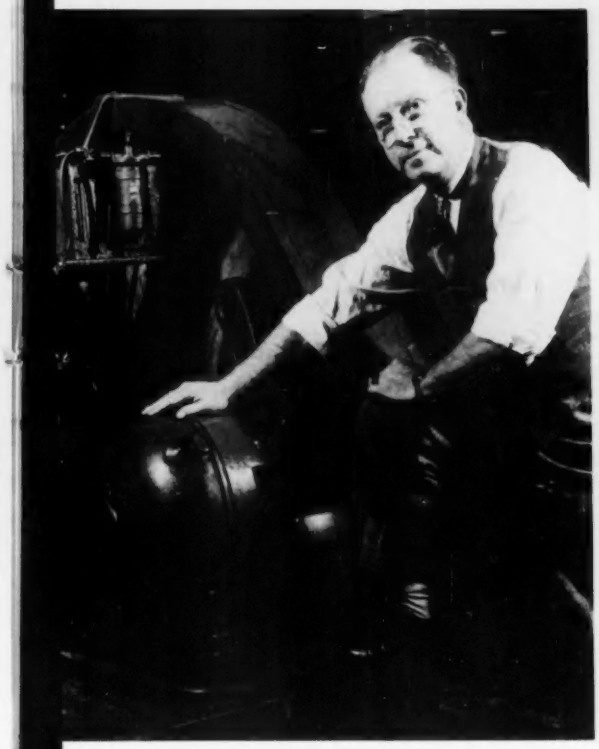
GE

TRI-CLAD MOTORS

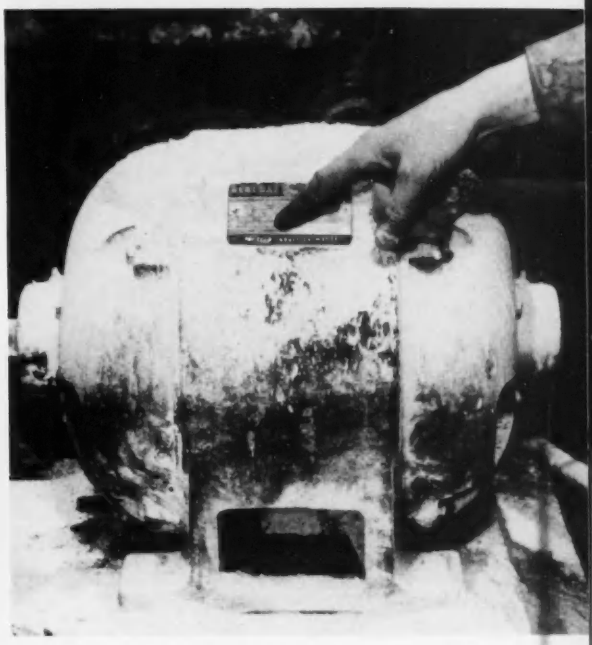
REG. U.S. PAT. OFF.

Help Keep ESNA Production Up!

PRODUCTION PUSHER General plant foreman Karl Kjellburg has the job of meeting "impossible" defense program manufacturing schedules. He's counting heavily on automatically fed machines like the Tri-Clad driven V. & O. press on his left; says, "This press inserts over 200 elastic fibre locking collars a minute in a ⅜" fastener. Driving it is a big job for a motor. Our Tri-Clads gave us no trouble during the war. We're counting on them again!"



TROUBLE SHOOTER TESTIFIES Ed Conk, ESNA's maintenance chief, must furnish reliable power wherever it's needed in the plant. He's got some definite ideas about electric motors; says, "We like a motor you can regrease easily *if you have to.* So far, we've had to regrease very few of our Tri-Clad motors. And those were either on hot spots or on particularly tough jobs. The point is—we *could* readily have regreased them all if it was necessary."



TOUGHEST... on the inside Extra protection against electrical breakdown is built into every Tri-Clad motor. Formex* wire windings, one-piece cast-aluminum rotor, double-end ventilation—these are features that prolong a general purpose motor's useful life.

TOUGHEST... on the outside Teeth rattling blows, dripping liquids, corrosive fumes—they're all in a day's work for Tri-Clad cast-iron construction. You get a rigid structure, too—one that won't twist out of line when you're bolting it down.

TOUGHEST... at the bearings A Tri-Clad motor will run safely without relubrication for as long as any general purpose motor you can buy. But, if the application does make relubrication a "must", you can grease your Tri-Clad without halting production.

** Reg. U.S. Pat. Off.*

How to Keep Your Motors in Shape for the Job Ahead!

TIMELY READING With every electric motor needed on the line, once again it's time to be a crank about motor care. That's why every motor user needs this General Electric manual. Tells how to spot motor and generator trouble before it happens, how to prevent serious breakdown, how to conduct a regular motor maintenance program. Order a copy for your maintenance department today! Use the coupon!

General Electric Company
Section 752-8
Schenectady 5, New York

Please send me my free copy of "How To Maintain Motors and Generators" (GET-1202)

Name_____

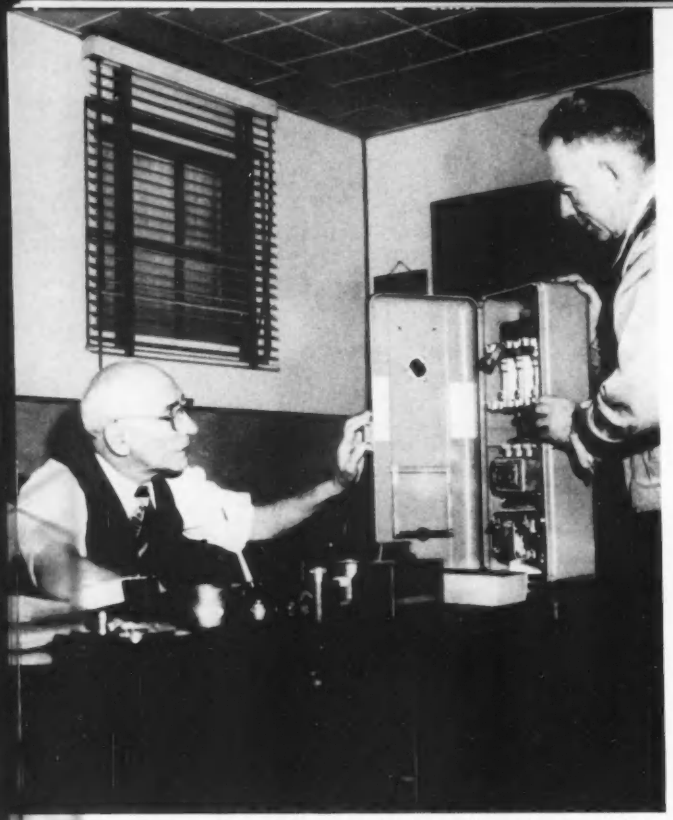
Company_____

Address_____

City_____ **State**_____

GENERAL ELECTRIC

You'll find some worthwhile information on motor control on the next page ➡



Herman F. Zoll, Purchasing Agent and Arthur B. Sullivan, Chief Engineer of John R. Evans & Co. inspect the G-E motor starter that is giving motors throughout their plant the reliable control and protection needed to keep output up, rejects down.

"...NO SHUTDOWNS DUE TO STARTER FAILURE!"

Here's a tip on real motor-starter dependability from a leather-processing plant executive

As chief engineer of a leather-processing plant, it's Mr. Arthur B. Sullivan's job to keep electrical equipment throughout the plant running smoothly. So it's a safe bet he knows what he's talking about when it comes to motor-starter dependability.

Says Mr. Sullivan: "When a motor drive won't start because its motor starter fails, we're tied up until it's fixed. We lose output and, if it's a continuous processing line our rejects may be high.

"Because of this, we've had to compare starter against starter. We haven't found one that beats this G-E starter. Since installing it, we've had practically no shutdowns due to faulty starting. What's more, this G-E starter is easier to install and service. We're sold on it!"

Martin Kelly, Evans Co. Plant Electrician, removes arc hood on G-E motor starter that isolates and protects each contact in its own chamber.

MAKE SURE YOUR PLANT ELECTRICIAN KNOWS ABOUT THESE G-E STARTER FEATURES:

For Longer Life

Fine silver contacts, "Strongbox" Magnet Coil, "molded-in" coil lubricant.

For Easier Maintenance

A screwdriver is the only tool needed for servicing. All terminals are "up front".

For Greater Flexibility

Contacts that are easily changed from normally open to normally closed.

For details on the full line of G-E magnetic motor starters, write for Bulletin GEA-5153. Manual starters for infrequent starting operations are described in Bulletin GEA-1522. For pricing and shipping data, phone or write your G-E representative or authorized G-E distributor. *Section A730-21, Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

730-21

DUCTILE IRON

A Revolutionary Metallurgical Development

DUCTILE IRON is a cast ferrous product which combines the *process advantages* of cast iron with many of the *product advantages* of cast steel.

No longer in the pilot-plant stage, this new material is now produced and sold on the basis of specifications. Not only are its individual properties exceptional, but no other common engineering material provides such a combination of excellent castability and fluidity, with high strength, toughness, wear resistance, and machinability.

Actually, "ductile iron" denotes not a *single* product, but rather a family of ferrous materials characterized by graphite in the form of spheroids . . . a form controlled, in a broad sense, by small amounts of magnesium. Presence of spheroidal rather than flake graphite gives this new product a ductility that is unique among gray cast irons.

Four important types of ductile iron now being produced commercially are tabulated below.

REPRESENTATIVE MECHANICAL PROPERTIES OF COMMERCIAL HEATS OF DUCTILE IRON

	Grade	Tensile strength, psi	Yield strength, psi	Elongation per cent	BHN	Usual condition
A	90-65-02	95/105000	70/75000	2.5/5.5	225/265	As-cast
B	80-60-05	85/95000	65/70000	5.5/10.0	195/225	As-cast
C	60-45-15	65/75000	50/60000	17.0/23.0	140/180	Annealed
D	80-60-00	85/95000	65/75000	1.0/3.0	230/290	As-cast

A Pearlitic in structure. Provides good mechanical wear resistance.

B Pearlitic-ferritic in structure. Provides strength and toughness combined.

C A fully ferritic structure usually obtained by short anneal of either (A) or (B). Provides optimum machinability and maximum toughness.

D Higher phosphorous content than preceding grades, also higher manganese. Provides high strength and stiffness, but only moderate impact strength.

SOME UNIQUE PROPERTIES OF DUCTILE IRON

1. Its elastic modulus, about 25,000,000 psi, is virtually unaffected by composition or thickness . . .

2. It can provide a chilled, carbidic, abrasion-resistant surface supported by a tough ductile core. No other single material can combine these properties . . . its only counterpart being a tough material coated with a hard welded overlay.

3. As-cast ductile iron of 93,000 psi tensile strength has the same machinability rating as gray iron with a strength of 45,000 psi.

4. Annealed ductile iron can be machined at a rate 2 to 3 times that of good quality gray iron.

5. It can be satisfactorily welded.

APPLICATIONS

Automotive, agricultural implement, railroad and allied industries apply ductile iron, as-cast and heat treated, in components too numerous to detail.

Machinery, machine tools, crankshafts, pumps, compressors, valves and heavy industrial equipment such as rolls and rolling mill housings, utilize its high strength and rigidity.

In scores of engine, furnace and other parts serving at elevated temperatures, it provides oxidation and growth resistance heretofore unavailable in high carbon castings.

Other applications include paper, textile and electrical machinery, marine equipment, and pipe.

AVAILABILITY

Send us details of your prospective uses, so that we may offer a list of sources from some 100 authorized foundries now producing ductile cast iron under patent licenses. Request a list of available publications on ductile iron . . . mail the coupon now.

EMBLEM OF INCO SERVICE

The International Nickel Company, Inc.
Dept. PE, 67 Wall Street
New York 5, N. Y.
Please send me a list of publications on:

DUCTILE IRON

Name _____ Title _____

Company _____

Address _____

City _____ State _____

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Laboratory tests show

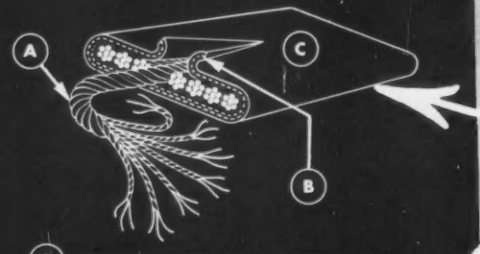
20 YEARS' SERVICE-PLUS

A LEADING gasoline-pump maker wanted a special flat belt to withstand severe service on his new reel-type pump — turned to the G.T.M.—Goodyear Technical Man—for recommendations. The Goodyear Steel Cable Flat Belt he recommended is still in excellent condition after 400,000 cycles on a laboratory tester *—more flexing than 20 years' service in the field will require!*

Wherever you use rubber in the products you design and manufacture—hose, belting, molded items or any other form—it will pay you to turn to the G.T.M. for help to be sure of the longest, lower-cost service. Write him c/o Goodyear, Akron 16, Ohio.

GOODYEAR INDUSTRIAL RUBBER PRODUCTS

GM-Specified SPECIAL FLAT BELT for GASOLINE PUMP REEL POWER

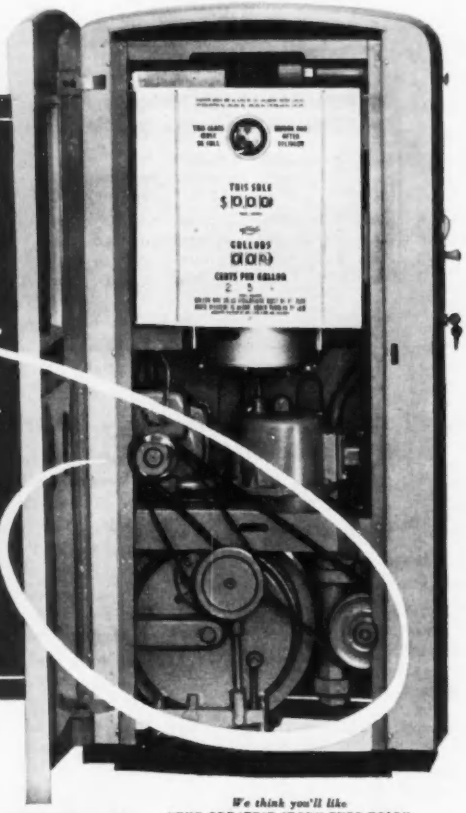


A – High-tensile airplane type, steel cable load-carriers

B – Rubber cushion section

C – Minimum coefficient friction cover permits controlled slippage when drive is off

½" width x 32" endless at factory



FOR HOSE, FLAT BELTS, V-BELTS, MOLDED GOODS, PACKING, TANK LINING, RUBBER-COVERED ROLLS built to the world's highest standard of quality, phone your nearest Goodyear Industrial Rubber Products Distributor or write the G.T.M., Goodyear, Akron 16, Ohio.

We think you'll like "THE GREATEST STORY EVER TOLD" Every Sunday – ABC Network

GOODYEAR

THE GREATEST NAME IN RUBBER

Steam on the beam

with "built-in" G-E CALROD* HEATERS

*Reg. U.S. Pat. Off.

Heat where they want it!

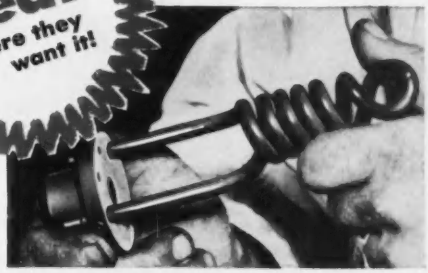
Madewell Products, Inc. puts steam on the beam in their Electro Spray with "built-in" G-E Calrod heaters!

Like hundreds of other machinery manufacturers, Madewell Products, of Oakland, California, have found that the simplest, easiest, most reliable way to build heat into their product is with G-E Calrod heaters. And in two years there hasn't been a single heater failure in the field!

Many times the heat source is a vital part of your machine. Because of the many types of G-E heaters...because of the wide range of standard sizes, ratings, and sheath materials in which these heaters are available . . . they provide a ready, practical solution to almost every conceivable problem of building low-cost, efficient heat into machinery.

Before You Design your machinery or equipment for repetitive manufacture, contact your nearest G-E Apparatus Sales Office and get the recommendations of an Industrial Heating Specialist . . . it will pay you BIG dividends. And . . .

FOR THE NEW, FREE 1950 CATALOG, GEC-1005A, write us on your letterhead. And, if you'll also tell us about your heating jobs, we'll send you application bulletins to help you select and correctly apply the right heaters to give you heat *where* you want it . . . *when* you want it . . . and in the *amount* you want it. ***Sect. 720-19, Apparatus Dept., General Electric Co., Schenectady 5, N. Y.***



The Calrod heater is easily formed into a helical coil, cast into brass concentric to a $\frac{1}{2}$-inch copper-tube coil, and the compact unit acts as a flash boiler.

The Madewell Electro Spray, generates superheated steam which blasts particles of insecticide into the air for prolonged suspension with increased killing effects.

GENERAL ELECTRIC

720-19

WHEN A PUMP MUST HANDLE
Widely Varying Heads

. . . the efficient, economical choice is a dependable Fairbanks-Morse Westco turbine type pump. These rugged, precision-built pumps are designed so that maximum capacity is obtained at an operating speed of 1750 r.p.m. when discharging at low pressure. High pressures are developed at the same speed with only a slight reduction in capacity.

Another important Westco advantage: you get multi-stage pump performance through the use of a single stage multi-vaned impeller.

These important Westco features make it a top choice where the pump must form an integral part of machines, units or systems. It is exceptionally compact. Capacities range from 1 to 200 g.p.m., with heads ranging up to 500 feet.

FAIRBANKS
A NAME WORTH

WHEN YOU NEED POSITIVE PUMPING OF ANY LIQUID
from Gasoline to Molasses

. . . the choice is Fairbanks-Morse Rotary Pumps. These positive displacement pumps efficiently handle any free-flowing liquid. Their exceptionally high efficiency, steady flow, freedom from vibration and non-fluctuating load characteristics assure long, economical service.

With only two moving parts, there are no complicated adjustment or service problems. Capacities range from 1.3 to 450 g.p.m.

Other FAIRBANKS-MORSE Pumps Include:

Single and Two-Stage Centrifugals

Builtogether Centrifugals

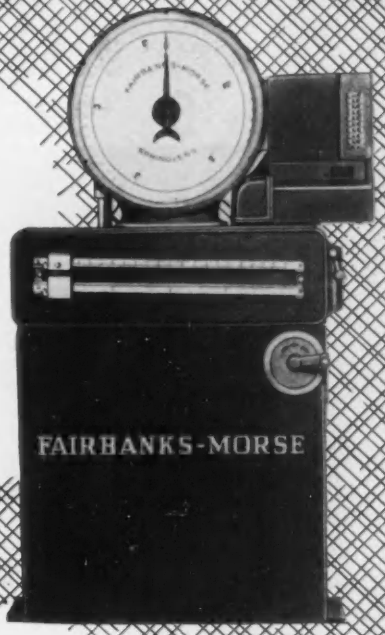
Side-Suction Centrifugals

WHEN A SCALE MUST DO

More than Weigh

. . . then Fairbanks-Morse Printomatic Weighers are your answer. In addition to automatically recording weights on a ticket or tape, these weighing instruments can, through the use of electronics, automatically control production and processing operations. They can be adapted for automatic control of batching processes, materials handling, and conveying systems. They can open and close gates or valves, controlling flow of material to predetermined quantities. Templets can be used to preserve formula secrets when compounding mixes.

Fairbanks-Morse Printomatic Weighers speed operations. They eliminate the chance for human errors . . . eliminate inefficiencies and losses caused by inaccuracies. Your Fairbanks-Morse weighing expert will be happy to help you fit a Printomatic to your operations.



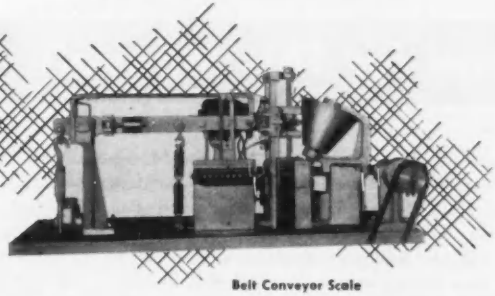
Printomatic Weigher

-MORSE

REMEMBERING

WHEN YOU MUST WEIGH

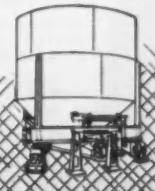
"On the Move"



Belt Conveyor Scale

. . . check Fairbanks-Morse Belt Conveyor Scales. These efficient, accurate weighing instruments automatically weigh material in transit . . . provide cumulative totals up to 1500 tons per hour. Installed as an integral part of the conveyor system, Fairbanks-Morse Belt Conveyor Scales speed weighing of incoming raw bulk materials and materials in process.

Whatever your weighing requirement, there is a Fairbanks-Morse lastingly accurate scale that exactly suits your needs. Fairbanks-Morse Scales or *component scale parts* can be supplied to fit right into your equipment for weight or control operations.

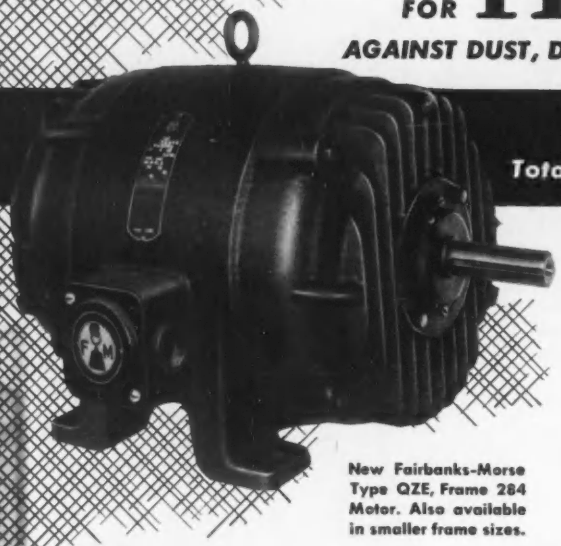


Hopper Scale

See next page for Fairbanks-Morse Sales Centers

FOR PROTECTION

AGAINST DUST, DIRT, ABRASIVES, STEAM, FUMES, ETC.



New Fairbanks-Morse Type QZE, Frame 284 Motor. Also available in smaller frame sizes.

FAIRBANKS-MORSE

Totally Enclosed, Non-Ventilated Motors

For the toughest operating conditions, here is the newest development in totally enclosed, non-ventilated motors. Fairbanks-Morse Type QZE Motors are now available in Frame 284—delivering 7½ hp. at 1800 r.p.m., 5 hp. at 1200 r.p.m—filling a long-standing need for this type and size of motor. New features that assure cool, long-running service include a unique end-bell construction with cooling fins for efficient heat dissipation—and for safe, uniform, internal temperatures. For the full story on the new dependability this class of QZE Motors can bring to your most severe motor jobs, ask your Fairbanks-Morse motor representative or write Fairbanks, Morse & Co., 600 South Michigan Ave., Chicago 5, Illinois.

FAIRBANKS

A NAME WORTH

FOR INFORMATION

ON DESIGN AND USE OF ELECTRIC MOTORS

Send for This Manual!

In this popular "Catechism of Electrical Machinery," you'll find an invaluable fund of basic information on the design, performance and proper use of the common types of alternating and direct current motors and generators. Primarily intended for training those who are not too familiar with electrical phenomena or terminology, it has been widely accepted by engineers, designers, and others as an aid in instruction of new men. It can be especially useful now, during this period of expanding and shifting employee rolls. Write your nearest Fairbanks-Morse Sales Center for your copy.

FOR SATISFACTION

IN SERVICES THAT ARE ROUGH ON MOTORS!

Compare these features

Superior Electrical and Mechanical Construction In All Fairbanks-Morse Type QZE Motors

Completely Protected Windings — No ventilating openings: impossible for any foreign matter to come in contact with windings.

Easy to install — NEMA standard mountings, interchangeable with standard, open-type motors of same ratings.

Grease lubricated ball bearings — permit sealing for the life of the bearing if desired.

Heat transfer air circulation — continuous circulation of captive air inside frame structure assured by rotor fans.

Convenient lubrication — protective covers or other parts need not be removed.

Reversible recessed conduit box — symmetrical construction allows easy reversal of stator frame.

COPPERSPUN ROTOR an Added Advantage

All Fairbanks-Morse Type QZE totally enclosed, non-ventilated motors offer the Fairbanks-Morse Copperspun rotor whose one-piece, virtually indestructible design and excellent electrical characteristics assure longer, more trouble-free life.

-MORSE

REMEMBERING

THESE ARE YOUR FAIRBANKS-MORSE SALES CENTERS

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AMhurst 7701

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BElmont 5258

BIRMINGHAM 1, ALA.
626 N. Ninth St. Zone 4
3-6546

BOSTON 10, MASS.
178 Atlantic Avenue
LAfayette 3-3600

BUFFALO 3, N. Y.
33 Franklin St.
Lincoln 4210

CHARLOTTE 2, N. C.
Liberty Life Bldg.
Room 605
6-3893

CHICAGO 5, ILLINOIS
1550 S. State St.
HArrison 7-7100

CINCINNATI 2, OHIO
49 Central Avenue
MAin 3010

CLEVELAND 14, OHIO
3000 W. 117th St.
CLearwater 1-3300

COLUMBUS 8, OHIO
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WAlnut 8581

DALLAS 2, TEXAS
1713 N. Market Street
CEntral 4347

DENVER 2, COLO.
1500 17th Street
TAbor 6241

DES MOINES 17, IOWA
2017 Dean Avenue
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DETROIT 13, MICHIGAN
11110 East Warren Ave.
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DULUTH 2, MINN.
Board of Trade Bldg.
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HOUSTON 13, TEXAS
5521 Navigation Blvd.
WAyside 2159—(LD 506)

INDIANAPOLIS 2, IND.
1499 N. Harding St.
FRanklin 3684
ATlantic 3092

JACKSONVILLE 6, FLA.
930 East Adams St.
5-6473

KANSAS CITY 7, MO.
1300 Liberty Street
Victor 6474

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JEfferson 8151

LOUISVILLE 8, KY.
2008 So. Brook St.
CAlhoun 1469

MEMPHIS 7, TENN.
676 Jefferson Ave.
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MILWAUKEE 3, WIS.
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EAst 0131

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187 Pine Street
GAspee 1-1531

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217 South Eighth St.
CHestnut 7483

ST. PAUL 1, MINN.
220-26 E. Fifth Street
GArfield 4335

SALT LAKE CITY 1, UTAH
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3-2108 & 3-5139

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EXbrook 2-5855

SEATTLE 99, WASH.
Salmon Bay Terminal
ALden 6600

STUTTGART, ARK.
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TULSA 3, OKLA.
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WASHINGTON 5, D. C.
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District 6694

FAIRBANKS-MORSE de MEXICO S. A.
Balderas 146, Mexico 1, D. F. Mexico
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Export Division:
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80 Broad Street—HAnover 2-7470

High speed shaper keeps in shape with TIMKEN® bearings

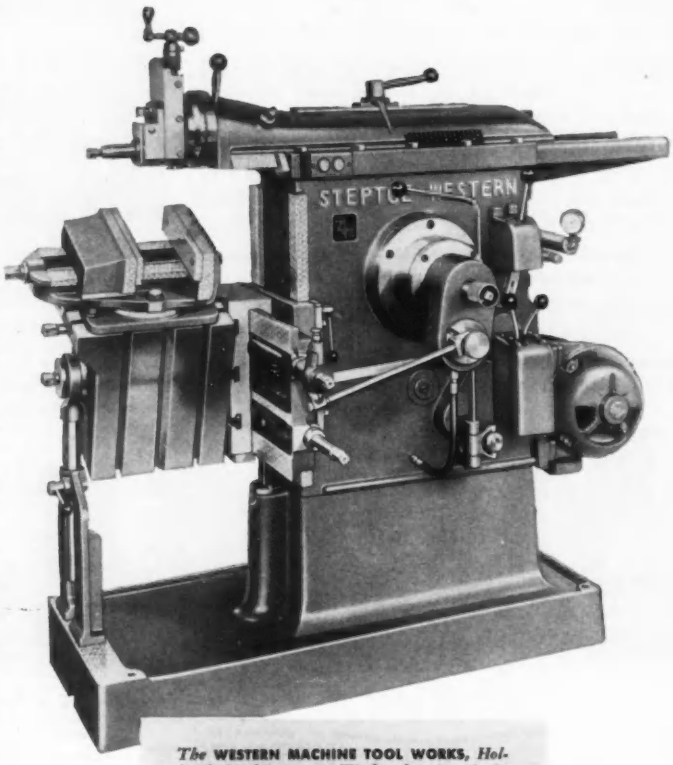
THIS Steptoe-Western 15″ shaper is one of the fastest precision shapers in its class. It has 18 ram speeds and works up to 200 strokes per minute. To insure precision and trouble-free operation, the Western Machine Tool Works has mounted the input shaft, three countershafts, and the main bull gear on Timken® tapered roller bearings—a total of 12 in all, with automatic pressure lubrication.

Timken bearings keep shafts in rigid alignment under the heaviest loads. Tapered construction enables them to take any combination of radial and thrust loads. Line contact between rollers and races gives them extra load-carrying capacity.

Manufactured to extreme precision and finished to incredible smoothness, Timken roller bearings make friction practically negligible. And since they're made of the finest steel ever developed for tapered roller bearings—Timken fine alloy steel—they last the life of the machine.

With 50 years of bearing research and development back of them, Timken bearings are first choice throughout all industry. No other bearing can give you all the advantages you get with Timken bearings. Look for the trade-mark "Timken" on every bearing you use. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



The **WESTERN MACHINE TOOL WORKS,** *Holland, Michigan, uses Timken bearings in its 12″ and 15″ shapers to insure consistent precision and trouble-free performance for the life of the machine.*

FINISHED TO CLOSER TOLERANCES

Finishing to incredible smoothness accounts for much of the precise, smooth rolling performance of Timken bearings. This honing operation is typical of the amazingly accurate manufacturing methods at the Timken Company.

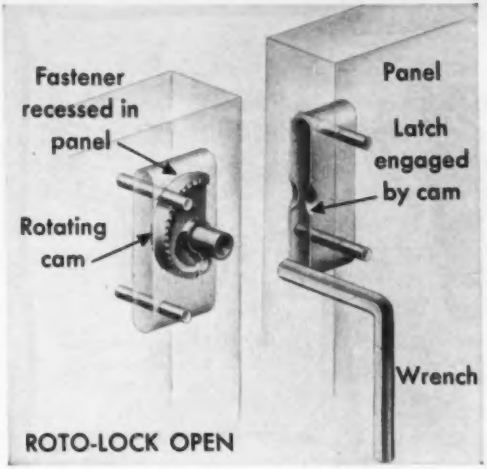
The Timken Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

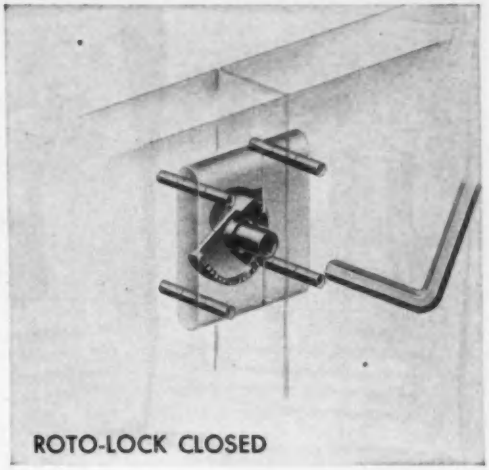
TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⬮ AND THRUST ⬮ LOADS OR ANY COMBINATION ⬮





More than a fastener...

a revolutionary construction principle

ROTO-LOCK makes butt or right-angle joints quickly and securely... simplifies demountable construction

Roto-Lock, the ingenious Simmons locking device, works with just a twist of a wrench... a cam pulls parts together. When gaskets are placed between panels, Roto-Lock exerts sufficient pressure to form a weatherproof, watertight seal.

Easily installed by unskilled labor in *any* material, this revolutionary Simmons Fastener is ideal for any type of demountable construction—from Army shelters or temporary hangars to lightweight knockdown shipping boxes, desks or tables. Recessing completely, Roto-Lock leaves no exposed parts when closed. It will fasten in misaligned conditions.

Built of materials highly resistant to corrosion and wear, Roto-Lock features design simplicity... has no springs or other delicate mechanisms affected by severe climates. Literature, showing numerous Roto-Lock applications and complete design specifications, is available to help you solve *your* fastening problems. Write for it today.

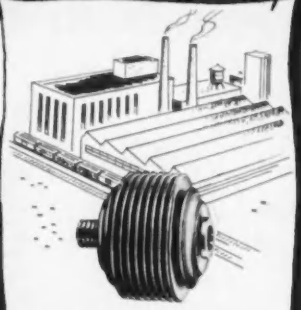
SIMMONS FASTENER CORPORATION
1751 North Broadway, Albany 1, New York

Simmons

SPRING-LOCK • QUICK-LOCK • ROTO-LOCK

IN AIRCRAFT, bellows assemblies are used in carburetor altimeter controls, fuel and manifold pressure gauges, oxygen regulators, etc.

IN AUTOMOBILES, bellows assemblies are used in thermostats, fuel pumps, fluid couplings, torque convertors, etc.



IN INDUSTRY, bellows assemblies are used in fuel oil pumps, air compressors, gear boxes, valves, temperature and pressure controls, etc.

IS THERE A HYDRON BELLOWS ASSEMBLY IN YOUR FUTURE, TOO?

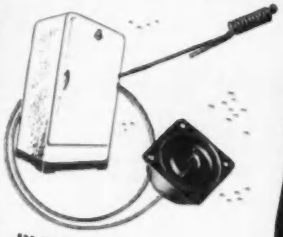
The Coupon Below Will Bring You the Answer

A Hydron bellows assembly can very well be just what you're looking for, if you are working on a problem in any one of these four categories:

1. Actuating switches or valves for accurate control of temperatures or pressures.
2. Sealing rotary shafts or packless valves against liquid or gas leakage.
3. Providing a flexible joint for instruments combining rotary motion and hermetic seal.
4. Transmitting motion hydraulically to remote points.

For these applications Hydron bellows can often save you time, money and design costs . . . and give you the most efficient device you could specify for the problem at hand.

INVESTIGATE! Clifford engineers will gladly make a confidential analysis of your sketches and specifications without cost or obligation. In the meanwhile, mail the coupon below today for up-to-the-minute facts about bellows and bellows assemblies.



IN ELECTRIC APPLIANCES, bellows assemblies are used as temperature controls and shaft seals.

CLIFFORD

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

CLIFFORD MANUFACTURING COMPANY, 122 Grove Street, Waltham 54, Massachusetts
Division of Standard-Thomson Corporation
Sales offices in New York, Detroit, Chicago, Los Angeles

FREE! **Please send me my copy of the bulletin "What to Consider When Selecting a Metallic Bellows". I am interested in the applications checked.**

- ☐ Air conditioning systems
- ☐ Aircraft
- ☐ Carburetor altimeter controls
- ☐ Engine thermostats
- ☐ Gasoline valves
- ☐ High pressure steam devices
- ☐ Heating equipment
- ☐ Instruments
- ☐ Remote or direct control of temperature and pressure
- ☐ Compensating regulators
- ☐ Electric or gas ranges
- ☐ Kilns & ovens — industrial
- ☐ Air compressors
- ☐ Oxygen flow indicators
- ☐ Oxygen regulators
- ☐ Process controls
- ☐ Refrigerating systems — commercial
- ☐ Shaft seal assemblies
- ☐ Fuel pumps
- ☐ Fluid couplings
- ☐ Supercharger controls
- ☐ Refrigerator controls — domestic
- ☐ Torque convertors

Other applications .....

Name ..... Title .....

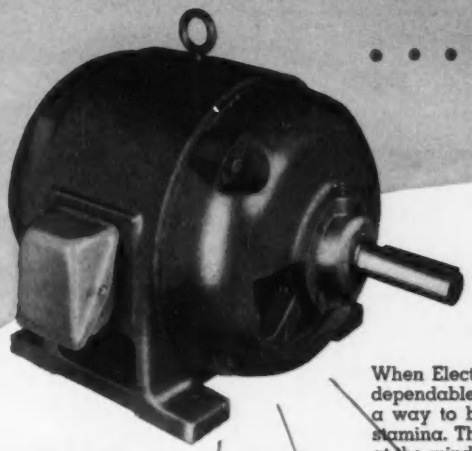
Firm .....

Street .....

City ..... Zone ... State .....

ELECTRO DYNAMIC MOTORS

are tough where toughness counts!



Extra Heavy-Duty *Windings*
Reduce Costly Motor Failures

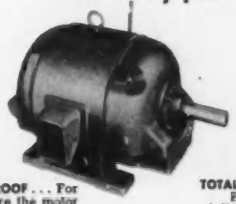
When Electro Dynamic was called on to manufacture super-dependable motors for submarines, our engineers developed a way to build electric motors with unusual toughness and stamina. Their method was to make the motors extra durable at the *windings*—"the heart of the motor".

That's why, today, special care and superior materials go into all E.D. windings. Furthermore, corrosion-resistant frames are of heavy cast construction. Every motor is dynamically balanced. As a result, you are assured of longer service, trouble-free operation and lower maintenance costs when you install E.D. industrial motors.

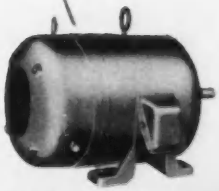
Find out how famous E.D. quality can improve your product and benefit your business. Write today for illustrated literature.

ELECTRO DYNAMIC INDUSTRIAL MOTORS are built in a wide range of types and sizes . . . 1 to 250 h.p. Shown above is an E.D. Drip Proof Industrial Motor. For use under ordinary industrial conditions not requiring protection from splashing liquids or from atmosphere laden with dirt or metal chips.

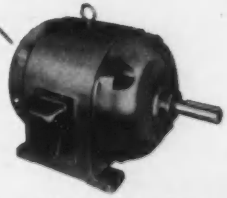
There's an E.D. MOTOR for every job!



SPLASH PROOF . . . For installation where the motor is subjected to splashing liquid or hosing down for cleaning.



TOTALLY ENCLOSED (Fan Cooled)... For dirt-laden atmosphere, especially where the installation requires a motor of compact dimensions.



TOTALLY ENCLOSED (Non-Ventilated)... For use in exceptionally dirty atmospheres, particularly when metallic dust is present.

Industry has learned what marine engineers have known since 1880

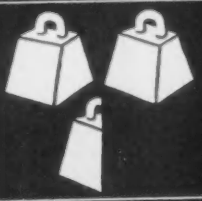
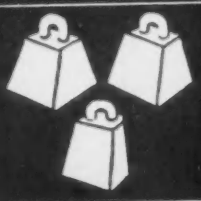
ELECTRO DYNAMIC
builds great motors

E.D. Also Makes a Complete Line of DIRECT CURRENT Motors and Generators. Literature on Request.

ELECTRO DYNAMIC • Division of the Electric Boat Company • Bayonne, N. J.

Examples of Savings of Metals.

DIE CASTINGS

PART	WEIGHT AND METAL IN DIE CASTING	SAVING OF METAL OVER OTHER METHODS
ALUMINUM BOOSTER CUP		
ALUMINUM FUZE HEAD		
ALUMINUM FUZE BODY		
BRASS BOOSTER CASING		

In the present emergency, Doehler-Jarvis is ready with 100 per cent increase in capacity since World War II, with seven plants located strategically in the following cities:

TOLEDO, O.

POTTSTOWN, PA.

GRAND RAPIDS, MICH.

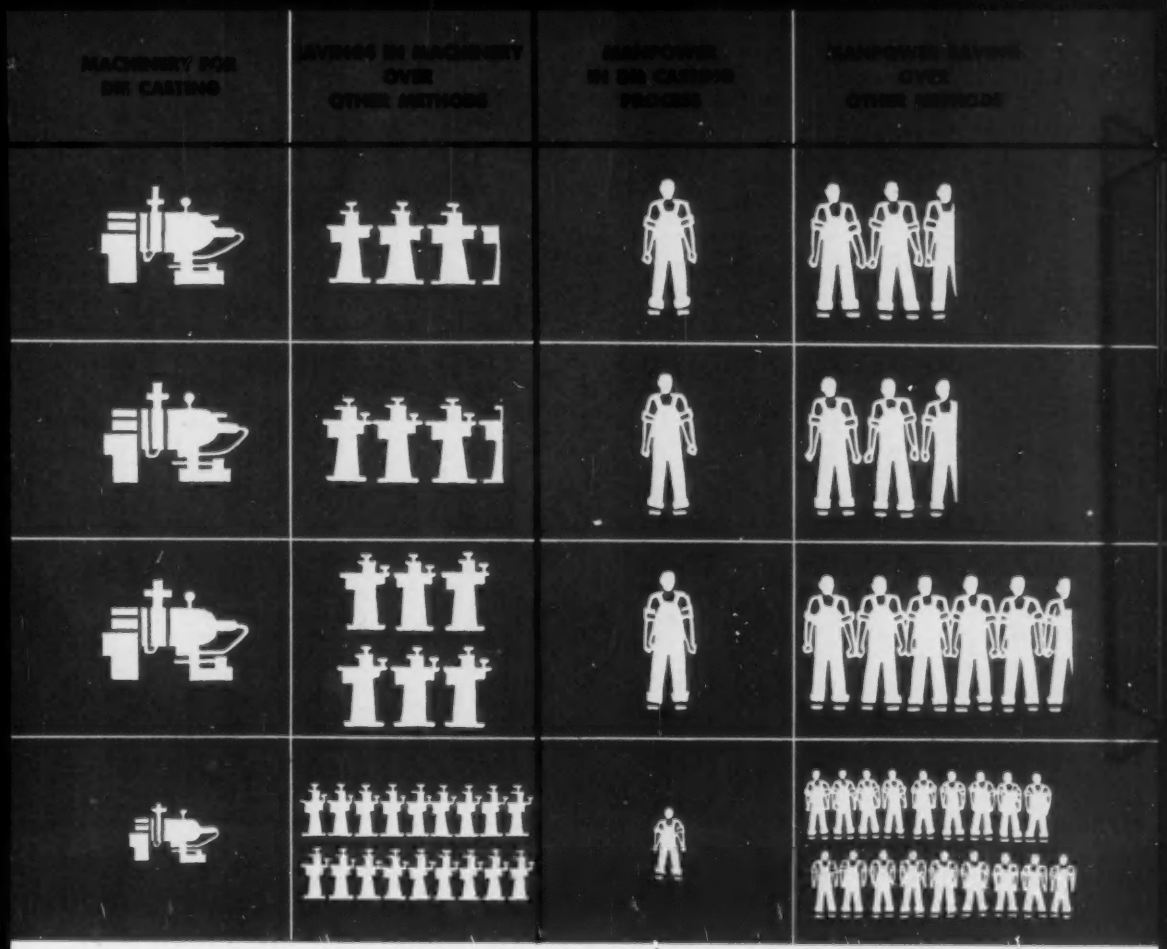
BATAVIA, N. Y.

CHICAGO, ILL.

Doehler-

Machines and Manpower by Using

in Armament Production


MACHINERY FOR DIE CASTING
SAVINGS IN MACHINERY OVER OTHER METHODS
MANPOWER IN DIE CASTING PROCESS
MANPOWER SAVING OVER OTHER METHODS

The World's Largest Producer and Finisher of Die Castings

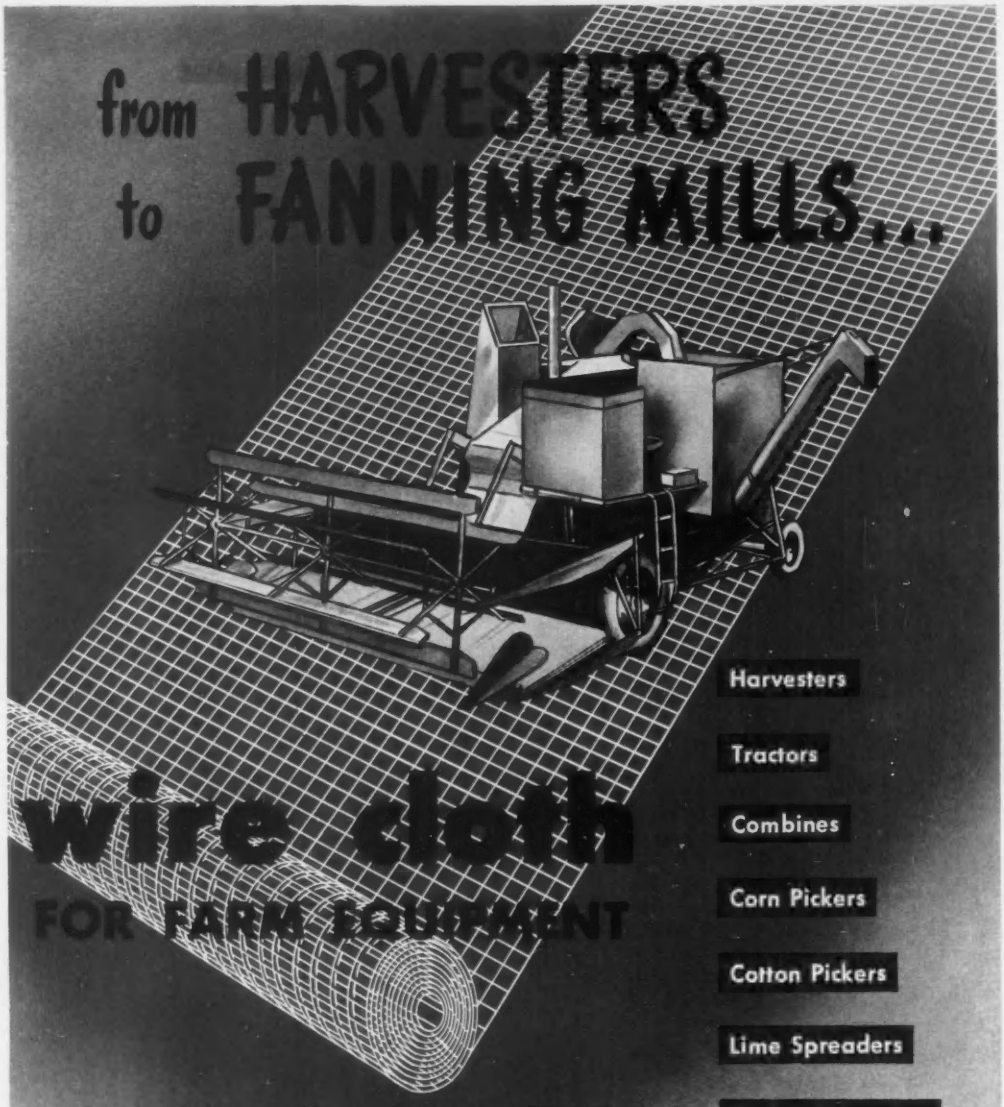
Jarvis

CORPORATION

Executive Offices, New York

DOEHLER-JARVIS

from HARVESTERS to FANNING MILLS...



wire cloth FOR FARM EQUIPMENT

Harvesters

Tractors

Combines

Corn Pickers

Cotton Pickers

Lime Spreaders

Orchard Sprayers

Fanning Mills

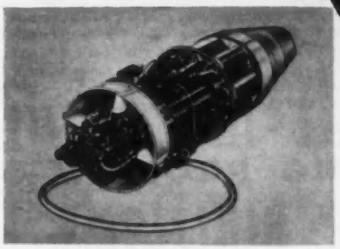
Even though the types of farm equipment are so different from each other... even though the uses of industrial wire cloth in that farm equipment are so many, and so wide, and so varied ... Reynolds wire cloth has proven its dependability over and over again. And yet farm equipment is only one of several industries that Reynolds wire cloth is serving so satisfactorily. Reynolds has more than fifty years' experience. A consultation on your wire problems costs you nothing.

REYNOLDS WIRE DIVISION
NATIONAL-STANDARD COMPANY

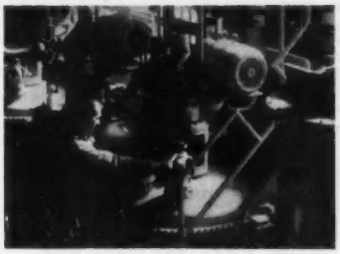
DIXON, ILLINOIS

NS NATIONAL-STANDARD Company NILES, MICHIGAN

HOW YOU PROFIT FROM WHAT G-E SILICONE RUBBER *won't do!*



O-rings for Turbojet Engine. G-E silicone rubber O-ring gaskets effectively seal two main parts of this Turbojet Engine against air and oil vapors at high temperatures.



Gasket on Chemical Reactor Temperatures as high as 350 to 400 F under high vacuum conditions are reached in this chemical reactor sealed by a G-E silicone rubber gasket.

**Address inquiries to Section F-2, Chemical Department, General Electric Company, Pittsfield, Massachusetts.*

New uses for parts fabricated by General Electric from its improved silicone rubber (G-E 12650) are being found—because of what it *won't* do. G-E silicone rubber is *inert* . . . won't react with metals, rubber and many chemicals.

This inertness makes G-E silicone rubber ideal for applications where corrosion or deterioration is a problem. Besides that, it has amazing resistance to heat and cold—plus excellent dielectric properties. Its improved mechanical strength makes it practical for use under high heat.

DEPEND ON G. E.

General Electric's *specialized* fabricating service is ideally equipped to supply the silicone rubber parts you need. This specialized service fabricates *only* silicone rubber compounds—your assurance of high-quality parts uncontaminated with other materials. Special molding and extruding techniques are employed, using G.E.'s own quality-controlled compounds, or any commercially available compound specified by a customer. General Electric, a pioneer in the development of silicone rubber, has tremendous "know-how" gained through designing hundreds of applications. Put this *specialized* fabricating service to work for *you!**

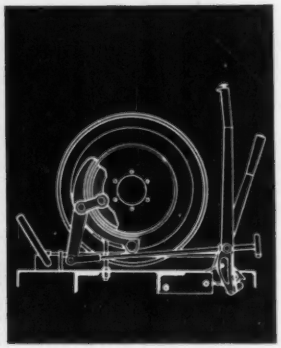
DEPEND ON G.E.'S SPECIALIZED FABRICATING SERVICE

GENERAL ELECTRIC

A Problem of Speed Plus Accuracy—

SMOOTH, RESPONSIVE BRAKES

GIVE POSITIVE CONTROL!



Because of the need for accurate and dependable control of rotation speeds under severe weather and working conditions, a TDA Duo-Grip Brake is standard equipment on the Halliburton Measuring Reel. The machine lowers a wire measuring line and instruments into oil wells at speeds up to 1,100 feet per minute. The manufacturer states: "This brake gives good braking effect with little effort on the brake lever without sacrificing sensitivity and accurate control." Some have been in service for three and one-half years without relining—a clear indication of their excellent performance!

WHATEVER *YOUR* BRAKING PROBLEM— TAKE IT TO TDA BRAKE DIVISION!

It's hard to think of a more important factor of machine operation than *control.* When the rotation of equipment must be retarded for a time—or brought to a full stop—this matter of control becomes a task for efficient, properly designed brakes. That is why more and more machine manufacturers are turning to TDA Brake Division. Backed by more than 40 years of concentrated experience in the field, thoroughly qualified specialists are available to analyze your brake needs and to supply equipment precisely engineered for your specific purposes. TDA Brakes can improve your product's performance and reduce your customer's maintenance expense. Mail the coupon below—*today!*

Here Are A Few Of The Many Products Which Can Be Equipped With TDA Brakes

Centrifuges • Compressors • Conveyors • Cranes Cream Separators • Diesel hook-ups • Dry cleaning machinery • Extractors • Hoists • Industrial electric trucks • Lathes (automatic) • Looms (textile) • Lumber mill machinery • Machine tools • Materials handling equipment • Motors • Packaging machinery • Paint mixers • Press brakes • Printing presses • Rolling mills • Shears • Warpers (textile) • Welding positioners • Winches • Automotive • Farm equipment Earth moving equipment • Construction equipment Public transportation

IF IT ROTATES WE CAN BRAKE IT

TDA BRAKE DIVISION—DEPT. A-1
ASHTABULA, OHIO

Please mail brake information on these applications.

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

TIMKEN Detroit BRAKES

TDA BRAKE DIVISION

THE TIMKEN-DETROIT AXLE COMPANY

ASHTABULA, OHIO

Accepted TDA Standard

TRADE MARK REGISTERED

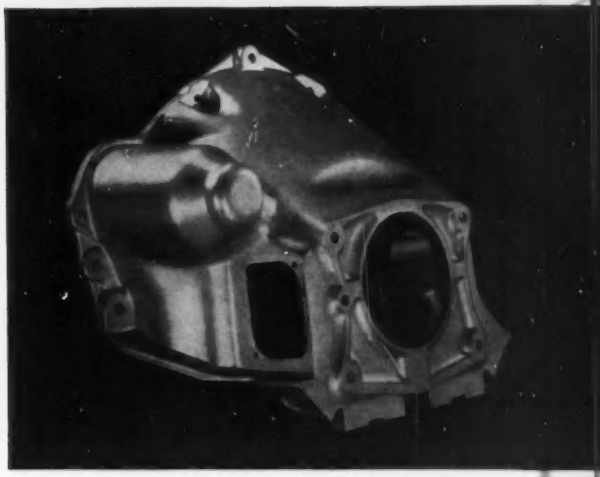
Aluminum

Government regulations limit the use of aluminum for other than essential projects. The facts presented here are to help you speed this essential work and get the most out of available metal.

Suggestions on how designers can utilize it for faster, lower-cost production . . . capitalize on advantages that only the light metals provide

CONTENTS

Aluminum Die Castings
Finishing Aluminum
Aluminum Forgings
Aluminum Extrusions
Aluminum Screw Machine Stock
Magnesium



Aluminum Die Castings

New developments are making possible larger and stronger die castings in aluminum. This case history of an automotive clutch housing shows how an Alcoa die casting made a part stronger and less expensive, too.

This clutch housing supports half the engine's weight. It is highly stressed, must absorb vibration. Originally, these housings were made of cast iron. Designers recognized the advantages to be gained by the use of a properly engineered aluminum casting.

After extensive development by our engineers, an aluminum die casting capable of withstanding the stresses was designed. Using a sand casting alloy of comparable mechanical characteristics to the die casting alloy selected, we poured sand castings and machined them to the die casting dimensions. Alcoa's Research Laboratories measured the casting's resistance to shear static loads, bending stresses and dynamic stresses. Using these test results, designs were modified and die-casting dies built.

While the auto maker conducted actual road tests with the *die castings*, we repeated the lab tests. Result: The die casting is 25% stronger in shear, 10% stronger in bending, 100% better in fatigue life, costs substantially less than the cast-iron product.

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA • 1807D GULF BLDG., PITTSBURGH, PA.

Finishing Aluminum

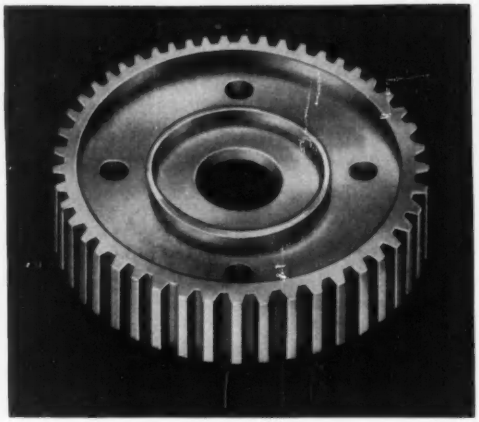
Aluminum takes all finishes — any that other metals will take, plus anodic coatings possible *only* with Aluminum

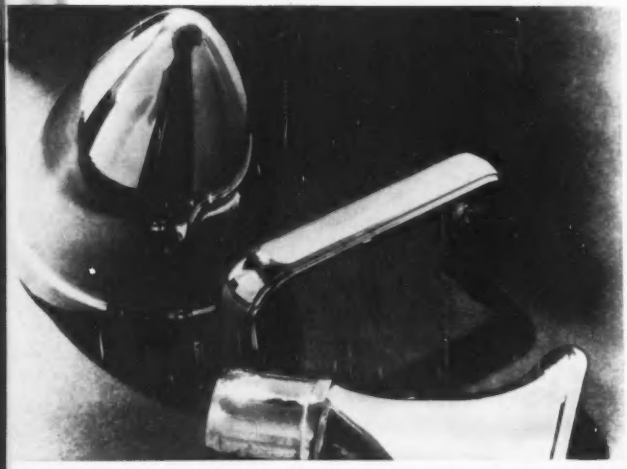
Aluminum is easy to plate by commercial processes

To simplify the plating of aluminum, Alcoa has developed the zincate-bath method. A 30-second to 1-minute immersion in this bath deposits a uniform layer of metallic zinc tightly bonded to the aluminum base. You can then plate with any metal and by any method compatible with zinc.

The zincate bath consists of 525 grams 76% caustic soda and 100 grams zinc oxide dissolved in water to make 1 liter. When suitably cleaned aluminum parts are immersed in this solution, the aluminum oxide film immediately dissolves, exposing the underlying metal. Some of the exposed aluminum then dissolves and is replaced by an equivalent weight of metallic zinc.

A copper strike is applied over the zinc-immersion layer. The zincate-bath method is less critical than others used in plating aluminum and gives uniformly good results.





If you need wear-resisting aluminum parts, you can give aluminum a "file hard" coating

To make aluminum suitable for applications once monopolized by stronger, harder metals, Alcoa has developed a special anodized coating. In this process, an integrally bonded oxide film of controlled thickness and predetermined hardness is deposited on aluminum parts.

Applications for this coating include bearing races, pistons, moving joints, and any parts where light weight must be combined with high resistance to frictional wear and abrasion.

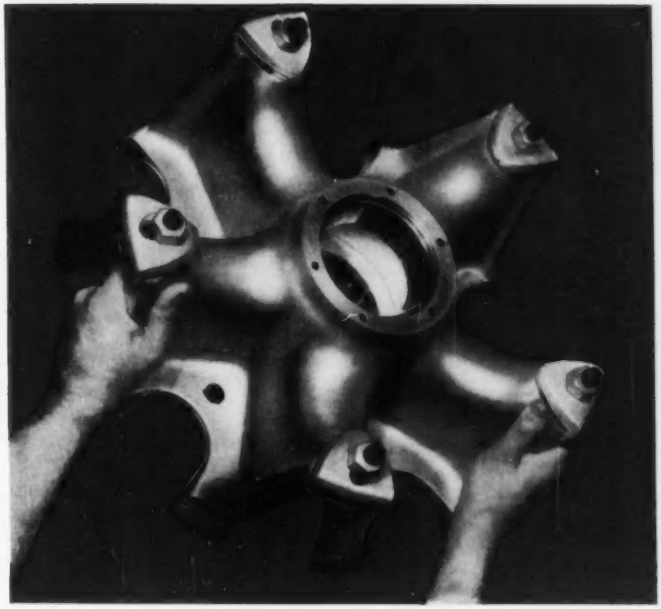
For a complete story on aluminum's remarkable affinity for every type of finish and every commercial finishing method, write for a copy of the 64-page book, "Finishes for Alcoa Aluminum."

ALCOA ALUMINUM ®

ALUMINUM COMPANY OF AMERICA • 1807D GULF BLDG., PITTSBURGH, PA.

Aluminum Forgings

Larger and more complex forgings are possible in aluminum than in any other metal. They compare favorably in strength with steel . . . can weigh a third as much.



Aluminum forgings, made by Alcoa, can combine strength and lightness to cut down dead weight that other structures must support. Can reduce vibration, inertia drag, bearing loads. Cut down wear and maintenance . . . lessen operator fatigue.

Aluminum's low elastic modulus provides several times the impact strength of mild steel. Aluminum forgings are used for vibrating parts, reciprocating parts, and other applications subject to repeated shock.

Surfaces of aluminum forgings are clean and bright because no scale forms during the forging process. This can eliminate finishing in many cases and, where protective coatings are called for, less surface preparation is needed. Since there are no surface irregularities, aluminum forgings develop high fatigue strength without the need for over-all machining.

Where machining is needed, aluminum's free-machining characteristic permits high-speed operations with minimum machining costs. Because aluminum can be forged to close tolerances, there is less metal to remove, less scrap loss.

With proper attention to design, aluminum forgings have uniform characteristics from piece to piece, with no internal flaws. This means you can design with lower safety factors than with other metals.

Since the design of aluminum forgings has important bearing on costs and performance, Alcoa has prepared a new 168-page textbook for designers. Write for your free copy of "Designing for Alcoa Forgings."

ALCOA ®

ALUMINUM COMPANY OF AMERICA • 1807D GULF BLDG., PITTSBURGH, PA.

Management was listening when this cop asked "WHY?"

They came to us with a questioning mind. Their oak trailer floors were heavy, easily damaged, replaced several times in a trailer's life. Moreover, state laws were tough on overloaded trailers.

These facts led the trailer maker to echo "why not increase payloads by making trailer floors lighter?" He came to us saying, "can there be a floor as strong as $1\frac{1}{4}$" oak—saving about 500 pounds—keeping costs low?"

The trailer maker and our engineers first explored aluminum plate and sheet formed into channels. Then an Alcoa man said, "let's try extrusions." Extrusions put the metal where it does the most structural good.

Together, we drew up designs, picked the most likely extrusion alloys from results of tests at Aluminum Research Laboratories. Samples were extruded. Experimental floor sections were built in Alcoa's Process Development Shops.

Now for testing. But no facilities existed for testing sections as wide as a trailer and $\frac{1}{5}$ as long. We built them. Then, working with strain gauges, we loaded the sections to failure. The best design was selected. The less expensive alloy proved strong enough.

Would aluminum floors last in service? Could they be installed easily? World-wide test stations and Alcoa laboratories provided data on aluminum's resistance to weather, salt spray and chemicals. Assembly experience demonstrated the ease of installation.

Extruded floors are now common. Seldom need replacement. Add extra cargo capacity. . . . Proof that it pays to be dissatisfied with your product. Proof that a long-range program of research and testing can change your company's competitive position.

ALCOA

there are no limitations on *Imagineering*

for such

1

Knowledge and Specialists

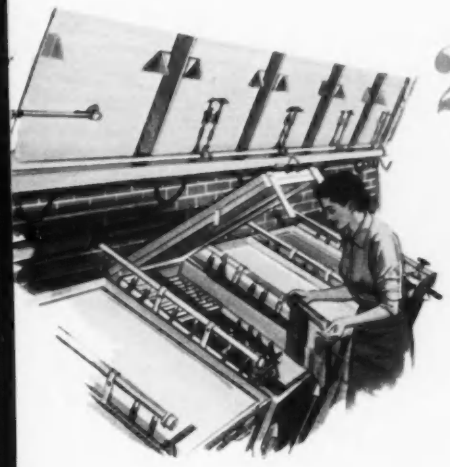
IN MANY FIELDS

- **Aircraft**
- **Architectural Specialties**
- **Automotive**
  - **Passenger Cars**
  - **Trucks and Trailers**
  - **Buses**
  - **Parts and Accessories**
- **Bearings**
- **Building Industry**
- **Business Machines**
- **Chemical Equipment**
- **Communications**
- **Corrosion Studies**
- **Diesel Engines**
- **Electrical Conductors**
- **Electrical Equipment**
- **Farm Machinery**
- **Food Equipment**
- **Handling, Packaging and Shipping**
- **Hardware**
- **Heat Exchangers**
- **Home Appliances**
- **Instrumentation**
- **Insulation**
- **Marine Industry**
- **Mining Equipment**
- **Paper Machinery**
- **Petroleum**
- **Pressure Vessels**
- **Printing Machinery**
- **Railroad Equipment**
- **Structural Engineering**
- **Textile Machinery**

Among these specialists at the Development Division are men already familiar with the problems of your industry. They are your liaison with the Alcoa research, test and fabricating facilities that can be put to work on your problem. Through them the sum total of Alcoa's knowledge will be brought to bear. Knowledge of practical problems of fabrication and costs, gained in thousands of other projects, will flow toward yours.

DEVELOPMENT DIVISION

long-range projects we have these to offer:



2 FACILITIES FOR BROAD *Research*

Like extruded floors, your project will require facts about the physical and chemical properties of aluminum. Perhaps a new alloy must be developed. Aluminum Research Laboratories have extensive facilities for this fact-finding job. Facilities such as this corrosion test equipment.

3 ADVANCED *Test* EQUIPMENT

Proving the theories of basic research requires testing equipment to duplicate every conceivable service condition. Even equipment like Alcoa's giant tensile tester or our 70,000 rpm whirlpit may not simulate the punishment your product must take. Then we design and build special equipment—like this set up for testing extruded flooring.

4 *Process Development Shops* FOR PILOT AND MODEL WORK

After thorough research and testing, the actual fabrication of your project in aluminum may pose further problems. Here Alcoa makes available all the techniques of welding, forming, machining, casting, heat treating and finishing to create a practical pilot model, then suggests low-cost, efficient methods for its fabrication.

ALCOA

For more details on the personnel, research and testing, and shop facilities available at Alcoa, write for your copy of the folder, "Road Map to a Better Product." It is your first step toward putting 63 years of aluminum knowledge to work on a long-term project that may effect a major change in your company's competitive position. Address ALUMINUM COMPANY OF AMERICA, 2185D Gulf Bldg., Pittsburgh 19, Pa.

Aluminum Extrusions

Almost any shape can be produced by Alcoa. Hollow, semi-hollow, solid . . . any form (within a 15-inch circumscribing circle diameter).

The biggest advantage of aluminum extrusions, made by Alcoa, is that they permit placement of the metal where good design calls for it. Put it where stresses are greatest and where maximum strength is needed, yet save metal as compared to roll forming or fabricating an equivalent section.

To help you visualize the almost limitless possibilities of aluminum extrusions, and to suggest ways in which you can adapt your designs to them, Alcoa has prepared a special booklet that's yours for the asking. Write for it today on your company letterhead. Ask for "Alcoa Aluminum Extruded Shapes."

Here's what the booklet contains:

— a discussion of design and production advantages of aluminum extrusions

— examples of aluminum extrusions that have increased strength and stiffness because of efficient metal distribution

— examples of designs that have been simplified by the use of a single extruded shape to replace expensive built-up assemblies, castings, or machining

— illustrations of the way several extruded shapes can be combined to simplify assembly and reduce costs

— data on size and shape limitations, alloys, section thicknesses, tolerances, die costs

— suggestions on modifying designs to utilize standard shapes for which dies already exist

ALCOA

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Aluminum Screw Machine Stock

Aluminum screw machine parts offer the designer many interesting physical properties. Their lighter weight can result in substantially lower costs.

Because aluminum is light in weight, a pound of aluminum may produce three times as many parts as a pound of steel or brass . . . usually enough to offset any difference in material cost.

Because aluminum can be machined easily and at high speeds, your parts can cost less to make in aluminum. Speed of machining is often limited only by the speed at which your machines can be operated.

Because aluminum is corrosion resistant, it is ideal for fittings and similar parts that are subject to corrosive conditions. Similarly, any aluminum components should be fastened with aluminum fasteners. This will prevent galvanic corrosion caused by contact of dissimilar metals.

Aluminum machines to an excellent finish . . . often needs no protective coating. But, if you want further finishing, aluminum takes any commercial finish that can be applied to other metals — plus anodizing, that is possible only with aluminum.

Magnesium

Lightest of commercial metals, its direct substitution for other materials often provides important ways to reduce weight and increase strength, as this case history shows.

Fruehauf Trailer Company Eliminates 560 Pounds of Dead Weight per Trailer with Light, Strong, Extruded Magnesium Floors

Designed as extruded sections, with deep, multiple channels, this flooring has none of the disadvantages of wood flooring . . . weighs 50% less, a saving of about 560 pounds in standard 30-foot trailer. In addition to light weight and high strength, it is free from splintering and warpage. It won't absorb water

ALCOA

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Magnesium (continued)

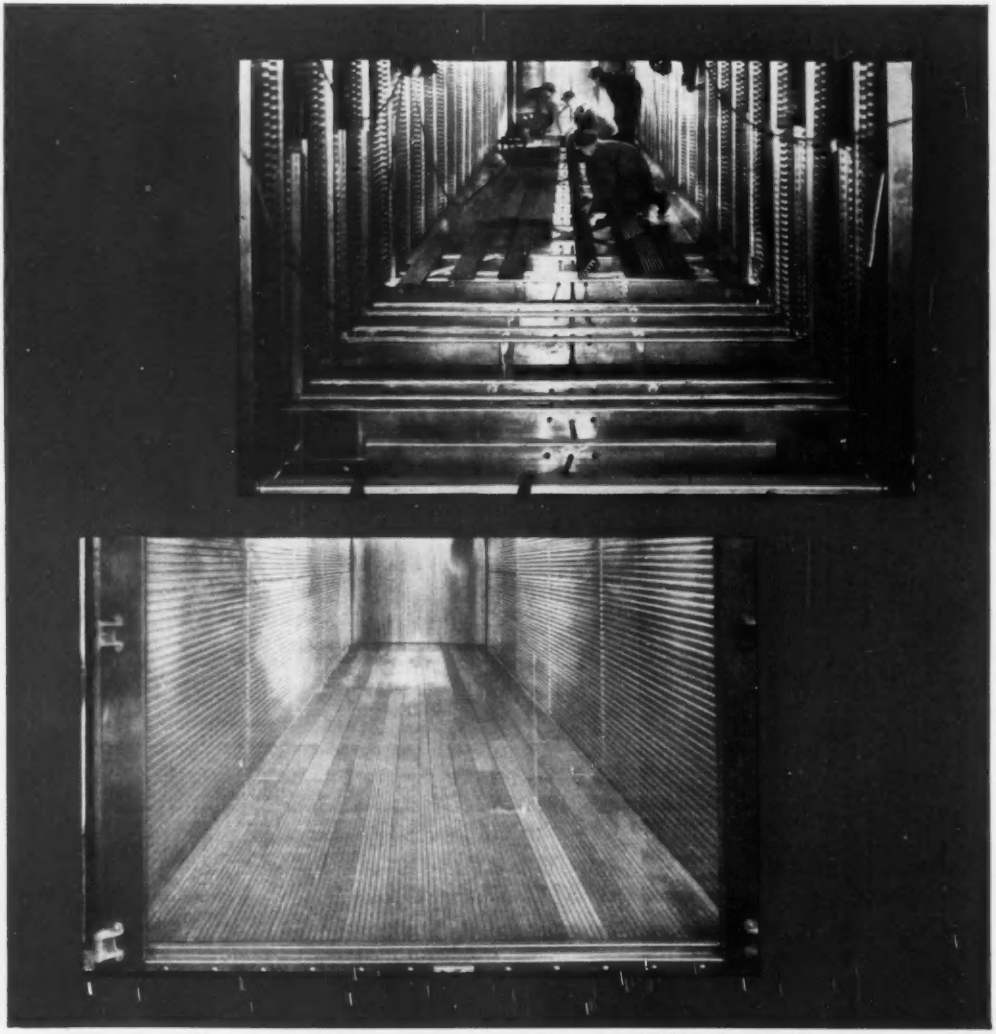
. . . is easy to keep clean and sanitary. It withstands the shock and abuse of lift trucks.

By utilizing magnesium and aluminum in its trailers, Fruehauf has reduced over-all weight by nearly 1200 pounds.

Due to its extremely low specific gravity, magnesium structures can usually be made lighter than aluminum, and considerably lighter than steel.

It can be cast, forged, extruded . . . joined by any method, including resistance welding and resin cements. It is the easiest of all metals to machine . . . can be machined at surface speeds impossible with other metals. Good housekeeping practices permit machining with complete safety.

Alcoa offers a 330-page textbook called, "Designing with Magnesium." You'll find it worth while to write for your personal copy.



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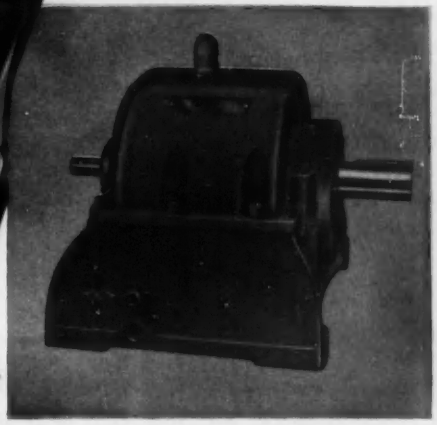


NOW!
New Space Savings
with speed reducers

A new series of concentric shaft type speed reducers has been added to the Westinghouse line of Geared Drives. This construction features straight-line mounting of speed reducer and prime mover, requiring a minimum of floor space.

Designated as "Type DB" speed reducers, these units are designed to economically transmit the inherently high speeds and efficiencies of electric motors. Power transmission efficiency averages 96%. Eight unit sizes are available over a range of 1 to 100 hp. Twelve standard gear ratios ranging from 6:25:1 to 58:3:1 are provided.

Included in these new speed reducers are the quality features common to all Westinghouse Geared Drives:

Single Helical Gears accurately hobbed on precision machines. BPT Taper Hardening produces tough, impact-resisting teeth.

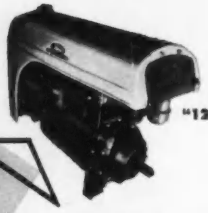
Split Case Construction permits easy accessibility. Strong, tight case heavily ribbed to provide extra strength.

Ample Lubrication by simple, positive splash system for both gearing and bearings.

For more information, write for DB-3700-1 SR. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-07299

YOU CAN BE SURE... IF IT'S
Westinghouse
GEARED DRIVES

YOUR job is Well-Powered when it's Ford-Powered



Ford "120" POWER UNIT

From the smallest

to the biggest

Ford
INDUSTRIAL ENGINES

• • • Ford Industrial Engines and Power Units offer a broad range of models—4-cylinder, sixes and eights—that cover just about every type of industrial application, and do it RIGHT. That's one big reason why more and more leading machinery and equipment builders look to Ford Industrial Engines and Power Units for the economical, reliable solution of their power problems.

Ford "337" POWER UNIT

FORD POWER IS RIGHT 3 WAYS

Just look at these typical applications

FORD "120" (4 cylinders, 120 cu. in.-displacement) —feed mills . . . concrete mixers . . . road sweepers . . . sprayers . . . ditchers . . . snowplows . . . material handling . . . welders . . . generator sets

FORD "226" (six cylinders, 226 cu. in. displacement) —hoists . . . pumps . . . feed mills . . . generator sets . . . material handling equipment . . . earth boring machines . . . airport tractors . . . bituminous spreaders

FORD "239" (eight cylinders, V-type, 239 cu. in. displacement)—portable sawmills . . . feed mills . . . hoists and cranes . . . pumps . . . generator sets . . . electric stand-by units . . . positive displacement pumps . . . compressors . . . concrete mixers . . . straddle trucks

FORD "254" (six cylinders, 254 cu. in. displacement) —road machinery . . . hoists and cranes . . . pumps . . . feed mills . . . logging equipment . . . portable sawmills . . . jetting pumps . . . frost protection machinery . . . drag lines . . . earth boring machines . . . rock crushers . . . generator sets

FORD "337" (eight cylinders, V-type, 337 cu. in. displacement)—logging equipment . . . portable sawmills . . . drag lines . . . railroad switch engines . . . coal recovery machines . . . asphalt plants . . . rock crushers . . . snow removal machinery . . . feed mills . . . road machinery . . . generator sets . . . hoists and cranes . . . pumps

☆

1. **RIGHT POWER**—*your choice of five great engines to fit your application*
2. **RIGHT FEATURES**—*all the latest advancements of Ford's famed progressive engineering*
3. **RIGHT SERVICE** *and Parts—as near as the nearest Ford Dealer*

☆

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Tractor & Industrial Engine Division
FORD MOTOR COMPANY
Highland Park, Michigan

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I am interested in Industrial Power for_____
Send me *new* 1951 literature about Ford Industrial Engines and Power Units
☐ "120" ☐ "226" ☐ "239" ☐ "254" ☐ "337" as checked

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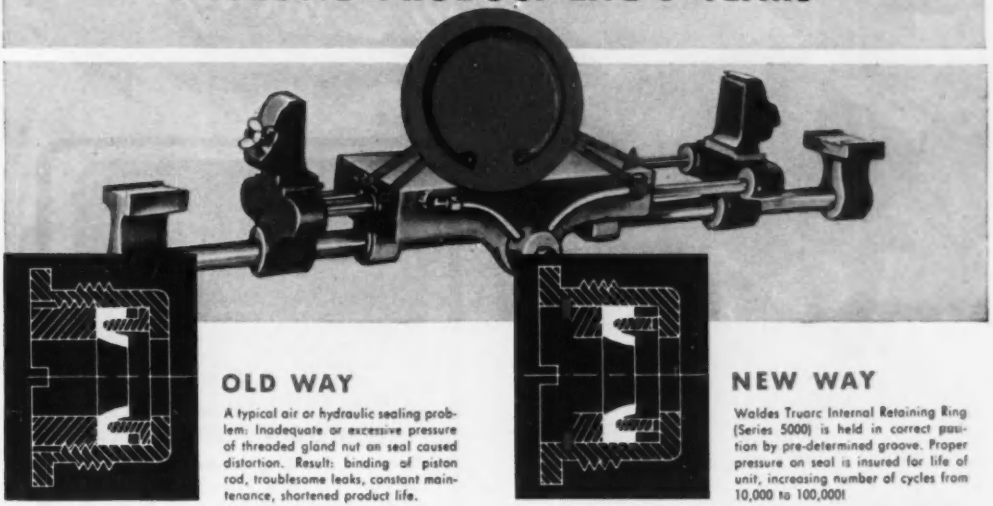
*Street*_____
*City*_____ *Zone*____ *State*_____

4 TRUARC RINGS CUT ASSEMBLY TIME 40%
CUT UNIT COST 25%
PROLONG PRODUCT LIFE 9 YEARS



OLD WAY

A typical air or hydraulic sealing problem: Inadequate or excessive pressure of threaded gland nut on seal caused distortion. Result: binding of piston rod, troublesome leaks, constant maintenance, shortened product life.

NEW WAY

Waldes Truarc Internal Retaining Ring (Series 5000) is held in correct position by pre-determined groove. Proper pressure on seal is insured for life of unit, increasing number of cycles from 10,000 to 100,000!

Using 4 Waldes Truarc Retaining Rings in their Check-N-Spect Air Power Units (for tire inspection and repair) saves Bowes Seal Fast Corp., Indianapolis, 40% in assembly time, 25% in cost. With Waldes Truarc Rings, assembly is simple... maintenance unnecessary. New design increases unit life from 1 to 10 years!

Redesign with Truarc Rings and you too will cut costs. Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better job of holding parts together.

Truarc Rings are precision-engineered... quick and easy to assemble and disassemble. Always circular to give a never-failing grip. They can be used over and over again.

Find out what Truarc Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

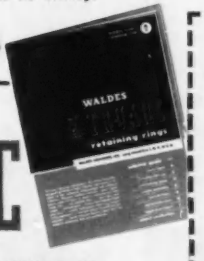
Waldes Truarc Retaining Rings are available for immediate delivery from stock, from leading ball bearing distributors throughout the country.

REDESIGN WITH 4 WALDES TRUARC RETAINING RINGS BRINGS THESE BIG SAVINGS...

- **Eliminates skilled-labor milling and threading operations** .....
- **Eliminates maintenance** .....
- **Gives greater accuracy in positioning seal** .
- **Saves 40% in assembly time** ..... **$.09**
- **Cost of old-type parts** ..... **.24**
- **Less Cost of four Waldes Truarc Rings** . **.08**
- **Net savings on parts** ..... **.16**

TOTAL UNIT SAVING... $.25

SEND FOR NEW CATALOG



WALDES

TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY THE FOLLOWING PATENT NUMBERS:
U. S. PATENTS 2,382,948; 2,420,021; 2,451,761; 2,487,803; 2,487,802; 2,491,308 AND OTHER PATENTS PENDING

Waldes Kohinoor, Inc., 47-16 Austel Place PN-043
Long Island City 1, N. Y.

Please send selector guide catalog (4k-w) on Waldes Truarc Retaining Rings.

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These are critical times for our nation. In the near future it is possible your plant facilities will be producing for defense. Valve construction and assembly problems may have to be solved in a hurry to meet crucial production schedules. The A. W. Cash Valve Manufacturing Corporation has twenty-seven years' experience in the development and construction of automatic valves for specialized domestic and industrial use. They have the facilities, the skilled personnel and are located in a self-sustaining, decentralized area. From one of the choicest manpower centers in the country, Cash-Acme draws the cream of American labor. These men and women are trained in the valve demands of your particular defense effort. Remember, when there's valve development or assembly work to be done, call on Cash-Acme. Write for the special prospectus which describes Cash-Acme's manufacturing facilities in complete detail.

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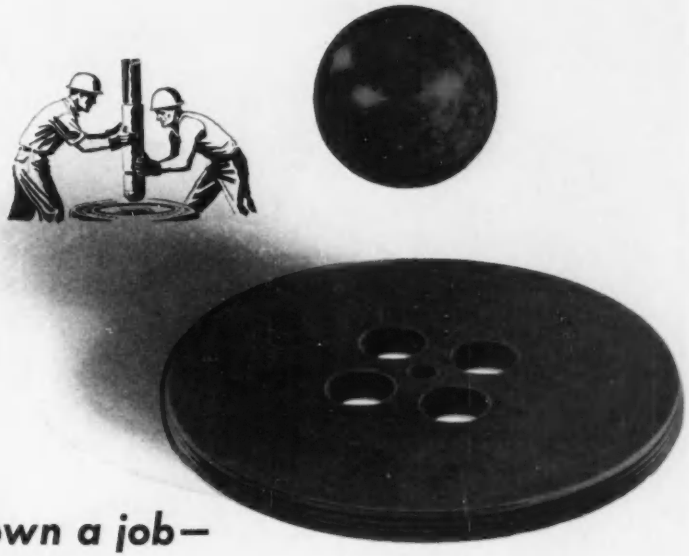

How to hold down a job— in a mile deep hole

When the well drillers have "made the hole" and an oil well is about to come in, a new job arises. And it's a real trick to handle, especially since there's a joker in it.

The job is to pump wet concrete into the hole to seal the sides. The joker appears because the shoe through which the concrete is pumped . . . the shoe that prevents the wet mix from backing up in the hole to seal it off . . . cannot be withdrawn after the mix has set.

The valve ball and thrust plate of the shoe, illustrated above, must be made from a hard, dense, tough material. They must resist the abrasive action of wet cement under considerable pressure. The ball must be dimensionally stable. Both parts must be moisture resistant. What's more, after the job is complete it must be easy to drill-out the working parts of the shoe to form a passageway.

This is a rare set of requirements. The makers of the Turbo Jet Float Shoe found in Synthane the material to meet them.

The Turbo Jet Float Shoe takes advantage of several Synthane properties. Other mechanical properties plus good electrical and chemical characteristics form an unusual *combination* which makes Synthane valuable for a wide range of applications. Synthane may be of help to you. To find out, send for the complete Synthane catalog. Address Synthane Corporation, 3 River Road, Oaks, Pa.

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if it's a wire spring .
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These advantages would be important to us.

"Idea generators" sounds interesting. Will you write for it?

Economical, handy, protective vials for hypodermic needles (above)... and scores of other types of products (left) are injection-molded of Lustrex styrene plastic by Celluplastic Corporation, Newark, N. J.

Injection-molded vial freezes habit-itis*

Hypodermic needles and phonograph cartridges... pharmaceuticals and cosmetics... saccharin and styptic pencils...hardware and denture materials—all these and many other products today are being *profitably* packaged in vials made of Lustrex.

"*Profitably*," because fast, accurate, one-shot injection molding of Lustrex styrene cuts production time and expense. Because lightweight Lustrex gives more units per pound of material, lowers shipping costs. Because stronger, more durable vials of Lustrex mean easier handling, less breakage and fewer returns.

Lustrex styrene is only one in a whole *family* of Monsanto plastics—each with its own individual chemical and physical characteristics—that might help you make or sell—a better product at lower cost.

For new plastics application ideas, send for your free copy of Monsanto's new booklet, "Idea Generators." Write: MONSANTO CHEMICAL COMPANY, Plastics Division, Room 1104, Springfield 2, Mass.

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*HABIT-ITIS—definition:—Habit-thinking; following familiar patterns of action from habit.

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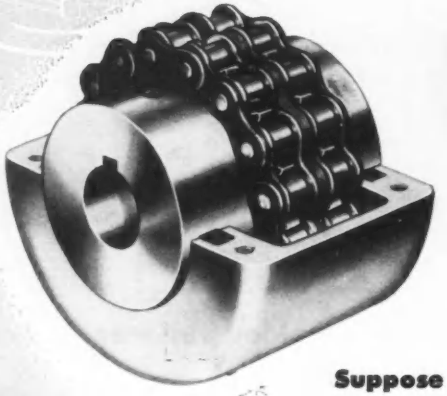

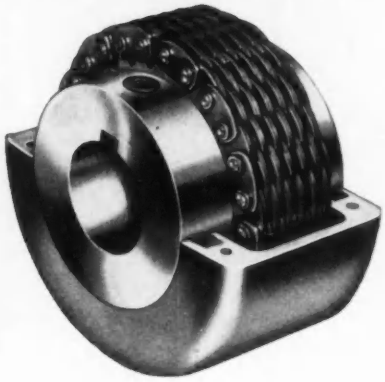

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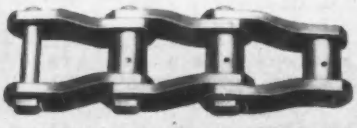

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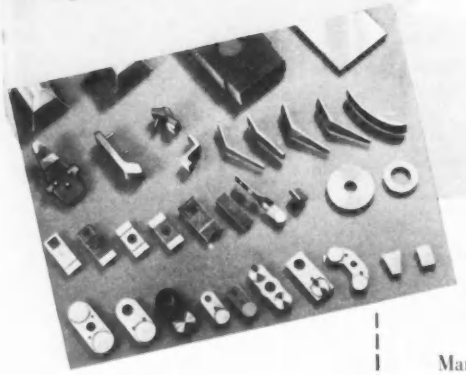

. . . *only* Mallory Elkonite *Delivers Top Performance*

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Elkonite contacts are made by a unique and time-proved method which permits the combining of the desirable features of basic metals which cannot be alloyed. By this means, the high melting points of tungsten, molybdenum, or their carbides, can be combined with the current-carrying ability of silver and copper. Elkonite materials are best known for their hardness, resistance to mechanical wear and impact, resistance to erosion by arcing (AR factor), and resistance to sticking.

Many years of pioneering in powder metallurgy of incompatible metals enabled Mallory to originate the Elkonite group of contact materials developed specifically for circuit breakers and other heavy duty electrical equipment.

Today, Elkonite continues to stand out among all powder metallurgy contact materials...by virtue of a superiority which stems not only from the properties of the constituent metals ***but also from the technique by which they are combined.*** Mallory engineers have so developed this art that no other material can equal Elkonite in conductivity, impact strength, hardness, AR** factor, and heat resistance.

Only by specifying true Elkonite, are you assured of top performance . . . the result of precision compounding and years of experience with powder metallurgy for contact applications.

That's value beyond specification!

Mallory contact know-how is at your disposal. What Mallory has done for others can be done for you.

**Reg. U.S. Pat. Off.*
***The ability of a contact material to withstand the erosion of an electric arc.*

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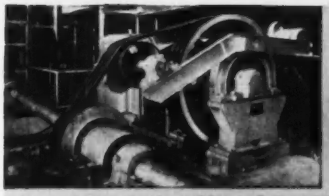
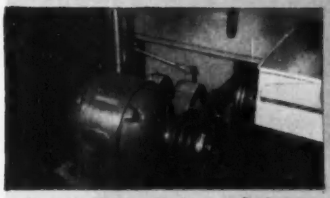


Paper Making Machine—Motion Control *Vari-Pitch* drive synchronizes paper machine sections.

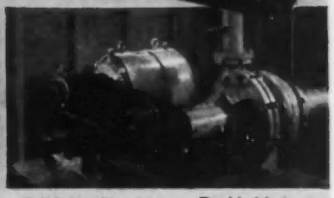
Air Conditioning unit — Stationary Control *Vari-Pitch* drive provides for seasonal adjustments.

TEXROPE Drives for Speed Control



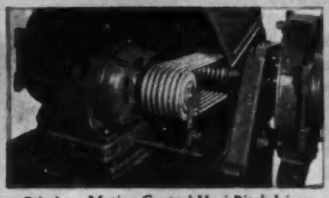
Cigarette Making Machine — Stationary Control *Vari-Pitch* drive provides for infrequent speed changes.

Pipe Threading Machine—Automatic *Vari-Pitch* drive gives simple, stepless handwheel speed changes.



Solids Handling Pumps—Double Motion-Control *Vari-Pitch* drive provides extra wide speed range.

Automatic lathe — Automatic *Vari-Pitch* sheave gives stepless speed changes for making ultra-fine finish.



Grinder—Motion Control *Vari-Pitch* drive holds cutting speed constant as diameter of wheel wears.

Conveyor — *Vari-Pitch* Speed Changer raises or lowers speed to meet production requirements.

HOW USERS PROFIT
With *Texrope* Adjustable Speed Drives

TAKE A TIP from these users. Get the speed you need for peak efficiency by adding *Texrope* variable speed drives. Best of all, no elaborate equipment — no special costly motors are required.

You'll increase efficiency . . . get maximum output when you adjust speed to meet variations in: the part processed; tooling; machine loading; and temperature and humidity.

There's a type or size *Texrope* adjustable speed drive to fit any requirement. Whether you need to change speeds rarely or frequently — when the machine is shut down, or when it's running — whether you're using one horsepower or 50, Allis-Chalmers can supply you.

In addition, Allis-Chalmers offers you more than the drive itself. A-C offers the extra engineering skill that naturally results from having more industrial V-belt installations than any other manufacturer. This in itself is important.

Get section 20P50 for complete engineering information on *Vari-Pitch* sheaves from your A-C Authorized Dealer or Sales Office, or write Allis-Chalmers, Milwaukee 1, Wisconsin.

Texrope and *Vari-Pitch* are Allis-Chalmers trademarks.

ALLIS-CHALMERS

Choose from These Types of Variable Speed Drives

VARI-PITCH SHEAVES for A-B, B, C, D, and E belts — speed variation 15% to 25% per sheave. Capacities 1 to 125 hp. Stationary type — for changing speed when motor is stopped. Motion Control type—for changing speed when motor is running.

WIDE RANGE VARI-PITCH SHEAVES for Q or R wide belts provide up to 2 to 1 speed range . . . fractional to 40 hp. Available in Stationary Control and Automatic types.

VARI-PITCH SPEED CHANGER — enclosed unit for adjusting speed while machine is in motion. Provides up to 3.75 to 1 speed range. Capacities 1 to 75 hp.

A-3262

NOW...you can get QD

TRADE MARK

QD

TRADE MARK

—ORIGINAL WITH WORTHINGTON
—STANDARD WITH ALL INDUSTRY

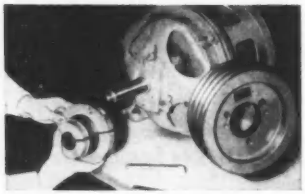
Today, more machinery is equipped with QD sheaves than with any other hub-and-rim combination.

The men who install and change sheaves prefer the convenience of its two-part, taper-mated construction and the permanent alignment of hub on shaft. Also, Worthington is the *only* manufacturer to design each size, individually, for the load it has to carry—rather than to proportion all sizes from one design. And the trim QD appearance is a sales asset.

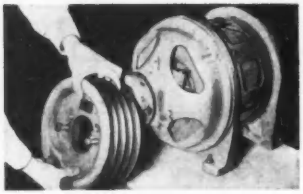
Specify Multi-V-Drive with QD sheaves and Worthington-Goodyear EC Cord V-belts on your machinery.

Write for Bulletin V-1400-B7F, addressing our Buffalo office.

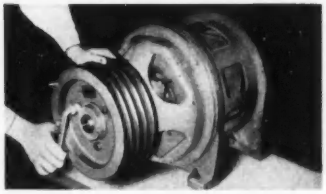
WORTHINGTON QD SHEAVE
THE ORIGINAL TAPERED CONE-GRIP SHEAVE



EASY TO GET ON



EASY TO GET OFF



YET ALWAYS TIGHT ON THE SHAFT

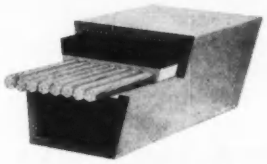
CHECK THESE QD FEATURES AGAINST ANY V-BELT DRIVE

...and you'll see why QD means easiest speed change and longest V-belt efficiency.

1. Sheave comes in two parts for easy mounting: light hub first, then heavier rim on tapered hub —or, as one-piece assembly.*
2. Split hub—easy to mount, even on over-size shaft.†
3. Interchangeable rims—hubs for every bore.†
4. Clamped hub holds position on shaft when rim size is changed —no realignment problem.*
5. Taper-mated hub and rim easily mounted in any position for friction cone grip and positive press fit on shaft.†
6. Shaft key lock prevents key from drifting.*
7. Large, long pull-up bolts hold better, and can be used as jack screws to remove rim.†
8. I-beam spokes on driven sheave help carry heavier load with less weight.*

* **WORTHINGTON EXCLUSIVE**

† **WORTHINGTON ORIGINAL**



WORTHINGTON-GOODYEAR EC CORD V-BELTS

Each endless cord carries its equal share of belt load—each belt carries its equal share of drive load. Cord location in neutral axis reduces internal friction.

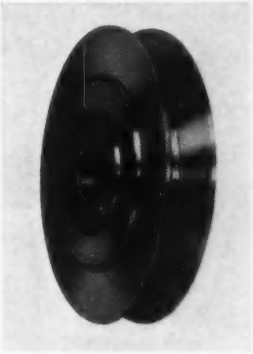
Also: steel cable V-belts for high capacity in minimum space, minimum stretch or creep: HY-T cord V-belts for shock load conditions.

advantages over the complete range of sheave sizes

...also FHP pulleys in other styles

QUICK-DETACHABLE V-PULLEYS FOR FHP DRIVES

The original Worthington QD Junior V-Pulley clamps the shaft tighter than any other FHP V-pulley on the market—and reduces maintenance time to a minimum. Taper-bored cast-iron rim, tightened on tapered split hub, creates a positive press fit on the shaft—won't loosen due to shock or pulsating load. Yet it's easily removed.



BORED-TO-SHAFT-SIZE SOLID MACHINED STEEL V-PULLEYS
—3½ in. and under

Precision-bored to insure proper fit on the shaft. The groove cross-section is accurate and uniform, so the belt seats properly and wears longer. A standard key seat is used with hollow head set screw.

PRESSED-STEEL V-PULLEYS

Quality at lowest cost. Heavy gauge, welded steel. Equal weight distribution assures accurate balance and vibrationless operation. Accurately formed grooves, precision bored. Available in a complete range of sizes and bores.

CAST IRON BORED-TO-SUIT V-PULLEYS

Accurately machined for true running and perfect balance. Complete range of sizes in single and two-groove.

FHP V-BELTS

A complete range. Elastic envelope takes wear, protects carcass, transmits load to heavy cords. Cord location in neutral axis reduces internal friction.

Write for Bulletin FHP-100 on FHP pulleys and FHP belts, addressing our Buffalo office.

WORTHINGTON

WORTHINGTON PUMP AND MACHINERY CORPORATION
MULTI-V-DRIVE SALES DIVISION
Buffalo, N. Y. · *General Offices*, Harrison, N. J.

THE GOOD RIGHT **HAND OF INDUSTRY**

POWER TRANSMISSION: sheaves, V-belts, variable speed drives

PUMPS: centrifugal, power, rotary, steam

AIR COMPRESSORS: water-cooled, air-cooled

MV-1-2

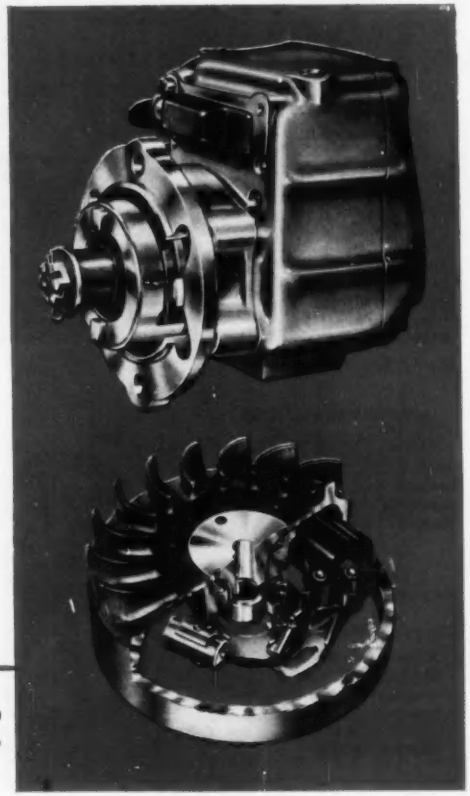
WOULD YOU LIKE
LONGER LIFE
and FREEDOM
from BREAKDOWNS
IN YOUR SMALL ENGINES?

Specify

BENDIX

THE MOST TRUSTED NAME IN MAGNETOS

- √ Simplicity in design.
- √ Waterproof moulded coil.
- √ Lower operating cost.
- √ Minimum lubricating requirement.
- √ Light in weight.
- √ Higher voltage at starting speed.
- √ Constant spark over entire speed range.
- √ Compact and sturdy construction.



Whether you purchase a small engine for outboard, industrial or marine use, today's foremost consideration should be long life and trouble-free performance. Therefore, it will pay you well to insist on Bendix magnetos in the engine you select. For the basic design of Bendix magnetos assures quality performance for *every type* of small engine and *every pricing requirement.* Remember it pays to specify Bendix, the most trusted name in magnetos. Complete information available on request.

SCINTILLA MAGNETO DIVISION of
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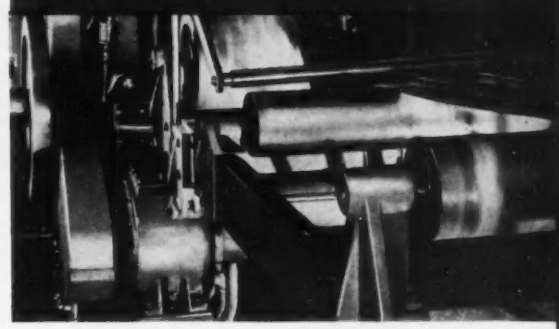
Saves Time, Money, Material

ON CHICAGO CARTON COMPANY
LAMINATING MACHINE

AND CUT-OFF



Oilgear drive installed in 1934 operates 16 hours daily at low cost. Gives maximum production on all stocks with little spoilage or non-productive time

A laminating machine and a cut-off in the plant of the Chicago Carton Company are driven in synchronism by Oilgear Fluid Power Equipment installed in 1934. A trip to the plant reveals today the compact, sturdy Oilgear equipment on the lower floor performing quietly, efficiently and continuously 16 hours a day in the necessarily humid atmosphere. Maintenance records indicate a total expenditure of $93.21 during the 16 years for service and parts, less than $6.00 a year. Because of the full flexible speed range and easy controllability of the Oilgear drives, the laminating machine is operated at speeds that best fit the type of board being processed and the cut-off drive follows in synchronism to cut stock into uniform lengths.

Another Oilgear feature important here is the unusual speed with which the laminating machine drive and cut-off drive can be started and stopped. This feature of Oilgear smooth, high speed acceleration and quick hydro-dynamic braking reduces non-productive time and cuts spoilage of sheets to a bare minimum.

On the basis of the 16 year performance of Oilgear, the Chicago Carton Company recently installed another Oilgear drive on a new 125 hp installation.

Time after time, Oilgear demonstrates its superiority and dependability on variable speed drives. Oilgear Fluid Power has many advantages. Investigate them now. THE OILGEAR COMPANY, 1571 W. Pierce St., Milwaukee 4, Wis.

UPPER—Oilgear 40 hp Variable Speed Drive with electric pilot motor remote control and oil reservoir base.

LOWER—Oilgear 7½ hp Variable Speed Drive with automatic control to synchronize cutter speed with speed of laminating machine drive.

Oilgear

PIONEERS IN FLUID POWER

PUMPS, TRANSMISSIONS, CYLINDERS AND VALVES

Built-In Klixon Motor Protectors

Safeguards "Spin-It-Fans" From Motor Burnouts

The "Spin-It-Fan," manufactured by Chelsea Fan & Blower Co., Inc., is unique in the fact that it permits users to exhaust air or have it blow air into the room . . . simply by turning on the switch and turning a knob in the desired direction.

The motor has *no* start winding. This simplicity is made possible by the Klixon Protector which protects the motor for overheating and burning out should the operator overlook turning the starting knob. Should the motor become dangerously overheated from any causes, the Klixon Protector prevents the motor from burning out by snapping the power "off." When the motor cools sufficiently, all the user need do is *push the red button* and the fan is ready to operate again.

You, too, can keep motors in your equipment operating by specifying and using Klixon Protected motors. They prevent motor burnouts, reduce repairs and replacements.

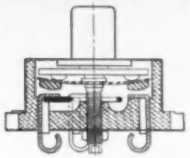
KLIXON

SPENCER THERMOSTAT

Division of Metals & Controls Corp.

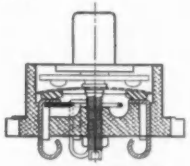
904 FOREST ST., ATTLEBORO, MASS.

Here's How KLIXON Protectors Operate:



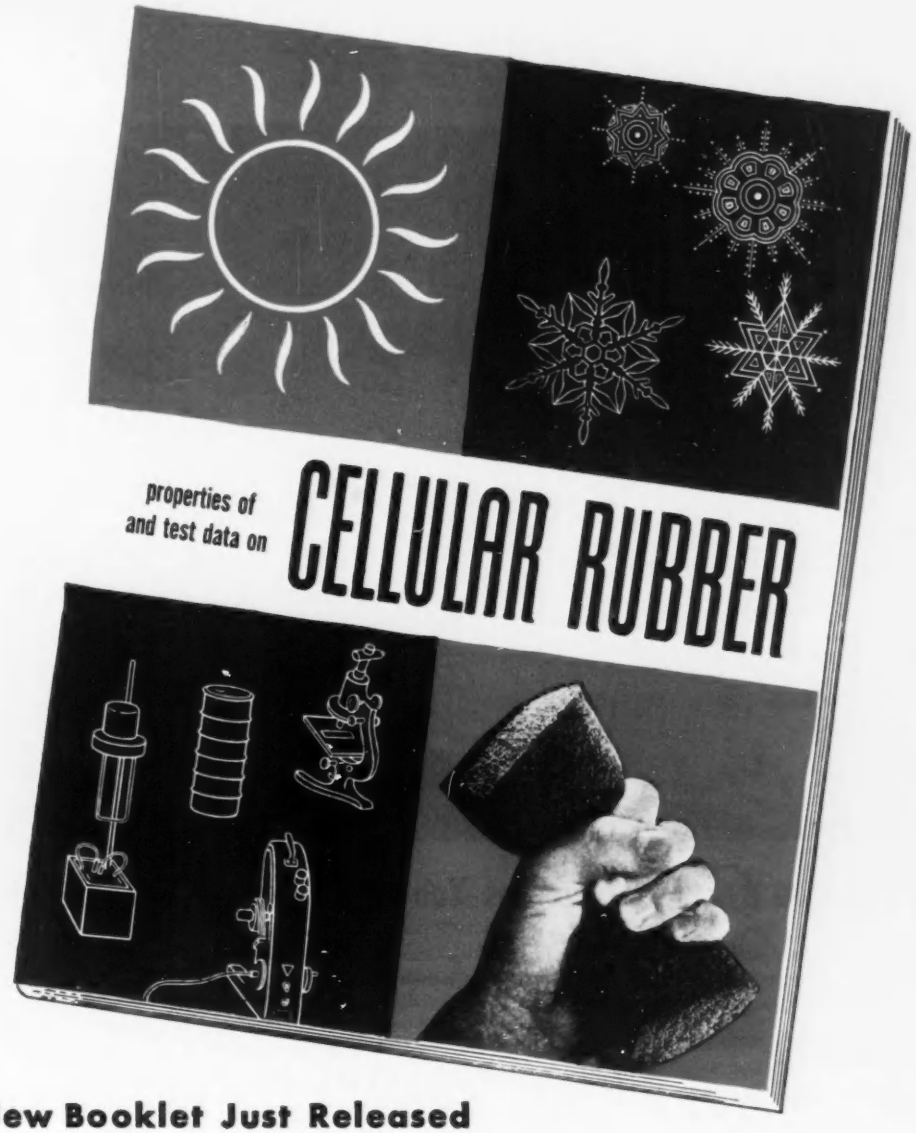
CLICK . . . IT'S OFF!

When temperature within the equipment reaches danger point, KLIXON Protector snaps the power "OFF" preventing burnouts.



CLICK . . . IT'S ON!

As soon as equipment cools to safe operating temperature, the KLIXON Protector automatically snaps the power "ON" again . . . or by pushing the button on manual reset type.



New Booklet Just Released

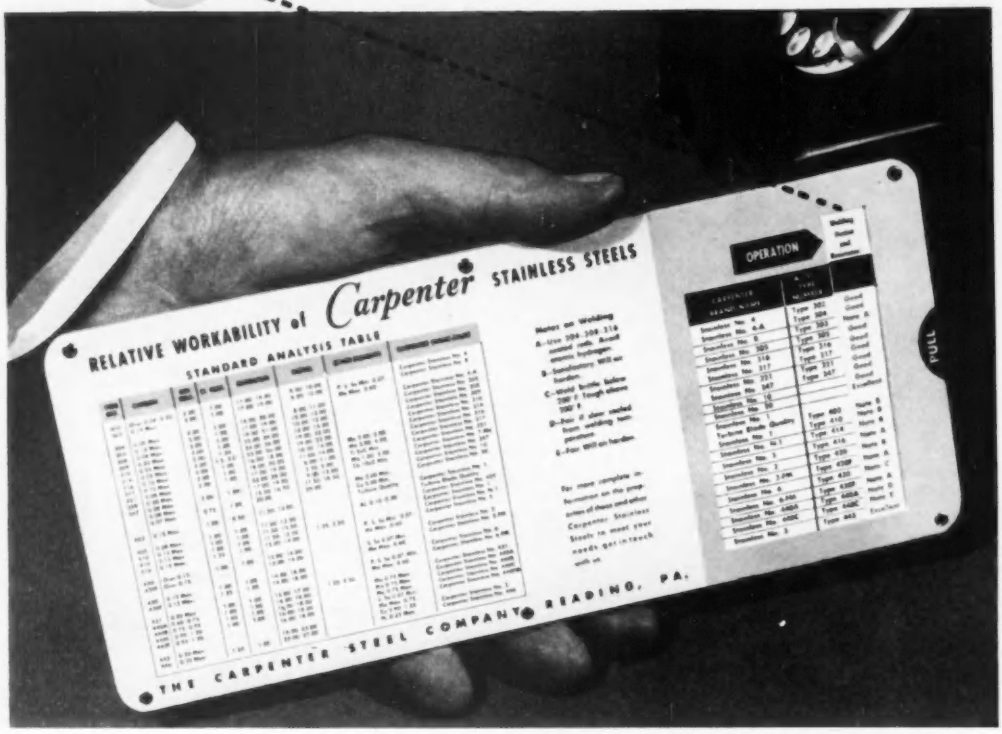
Send for your free copy of this up-to-date, authoritative work on the grades of, the chemical and physical properties of, and test data on cellular rubber. Lists A. S. T. M., Army, Navy and Air Force specifications, among others. The most complete reference work yet produced on this highly-adaptable product of widely diversified usage.

Write us today and your free copy will be mailed promptly.

THE SPONGE RUBBER PRODUCTS COMPANY

402 Derby Place — Shelton, Connecticut

MARKS THE SPOT



Where *Carpenter* Helps You in Your Work with Stainless

Getting better machined finishes, longer tool life and fewer rejects on Stainless jobs is the answer to—

- **increased production from every shift**
- **more parts from every pound of material**

To make Stainless Steel do its best for you, take advantage of the help Carpenter can provide. We'll be glad to give you personal help in the shop and useful printed information that makes it easier to work with Stainless.

The new Carpenter Stainless Slide Chart quickly gives you information your men need to know. It gives the relative workability for many grades, useful information for jobs where you do *blanking, deep drawing, forging, heading, machining, welding*, etc. You will also find a complete table of information on the physicals for the Stainless grades. Just drop us a note, on your company letterhead indicating your title, and we will put your Carpenter Stainless Slide Chart in the mail for you.

The Carpenter Steel Company, 117 W. Bern St., Reading, Pa.
Export Department: The Carpenter Steel Company, Reading, Pa. "CARSTEELCO".

Carpenter
STAINLESS STEEL
takes the problems out of production

For Easy-to-Use Stainless Call Carpenter! Warehouses in principal cities throughout the country.

Form DIFFICULT SHAPES WITH EASE WITH VINYLITE BRAND DISPERSION RESINS

Now you can achieve deep undercuts in finely detailed molding jobs, at low pressures and low cost... thanks to VINYLITE Brand Dispersion Resins! Their resistance to oils, greases, alkalies, most strong acids, moisture, aging, and abrasion gives them utmost value for such items as work gloves, coated floorings, rain boots, draperies, tool handles, dish drainers, to name a few.

VINYLITE Dispersion Resins permit extremely wide control over qualities such as color, softness, flexibility. They are tasteless and odorless. Elastomeric materials based on them can be used for spread coatings, dip coatings, paper or cloth coatings, cast film, or slush molding.

They may well be able to improve your products, step up your production, and lower your costs. We will gladly put you in touch with compounders using VINYLITE Dispersion Resins, and send you our technical data book, "VINYLITE Resins—Dispersion Coatings." Simply write Dept. KL-10.

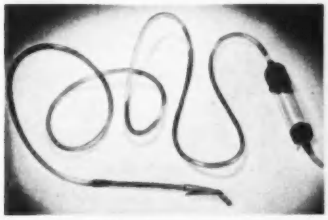
Vinylite BRAND **RESINS**

TRADE MARK

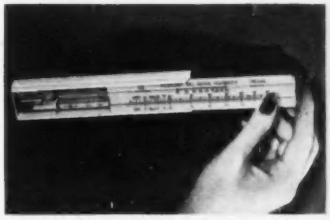
BAKELITE COMPANY

A Division of
Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

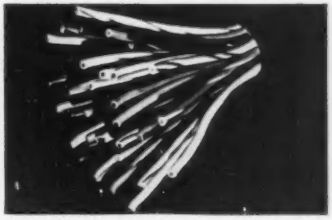
"Zany" Character Puppets by the Jay V. Zimmerman Company, 320 N. Leonard Ave., St. Louis, Missouri. Heads by Geneve Mfg. Corp., Trenton, N. J.



CHEMICAL INERTNESS, so essential to intravenous tubing used for blood transfusions, is achieved by extruding from VINYLITE Elastomeric Extrusion Compound. Transparent, flexible, easy to handle, odorless, chemical resistant, non-contaminating, the tubing is made by Sunlite Manufacturing Co., 1223 S. 23 St., Milwaukee, Wis.



DIMENSIONAL STABILITY. Consistent accuracy is assured by this slide-rule-type relative humidity calculator, whose VINYLITE Plastic Rigid Sheet parts hold their shape—despite temperature changes. Water, oil, chemical resistant. The Sillcocks-Miller Co., 10 W. Parker Ave., Maplewood, N. J.



LASTING RESISTANCE to acids, oils, alkalies, chemicals, moisture, corrosive atmospheres is given to insulated conductors in this circuit control cable by VINYLITE Plastic. Thinner walls save space, reduce weight. By Anaconda Wire and Cable Co., 25 Broadway, New York, N. Y.

50th YEAR

OF CERAMIC LEADERSHIP

APRIL, 1951, marks the beginning of the 50th year of American Lava Corporation's ever growing services to users of custom made technical ceramics. We are proud of this record and are genuinely grateful to the customers who have made this growth possible. To our customers we dedicate our future to a continuance of the type of services and quality of products that will contribute to the success of expanding American industries.

AMERICAN LAVA CORPORATION

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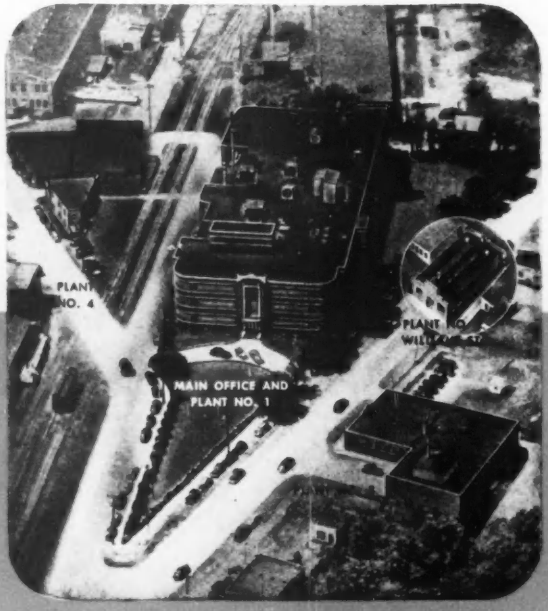
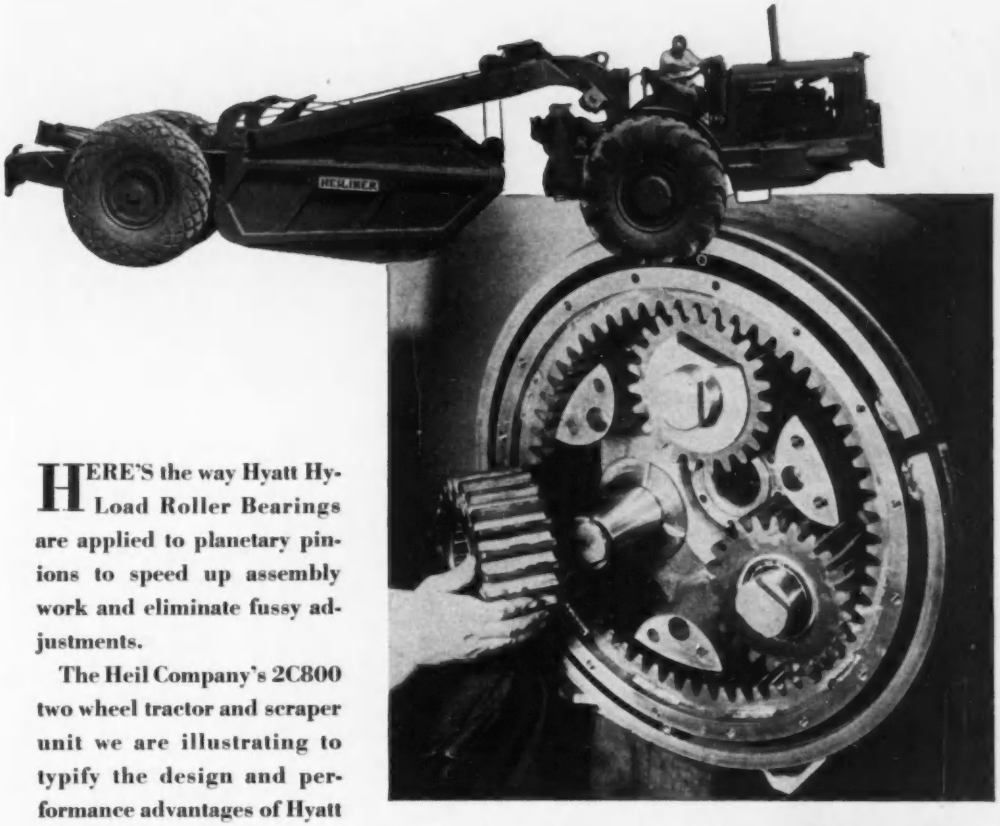
CHATTANOOGA 5, TENNESSEE



AlSiMag®

Another Example of Improved Design and Performance with HYATTS



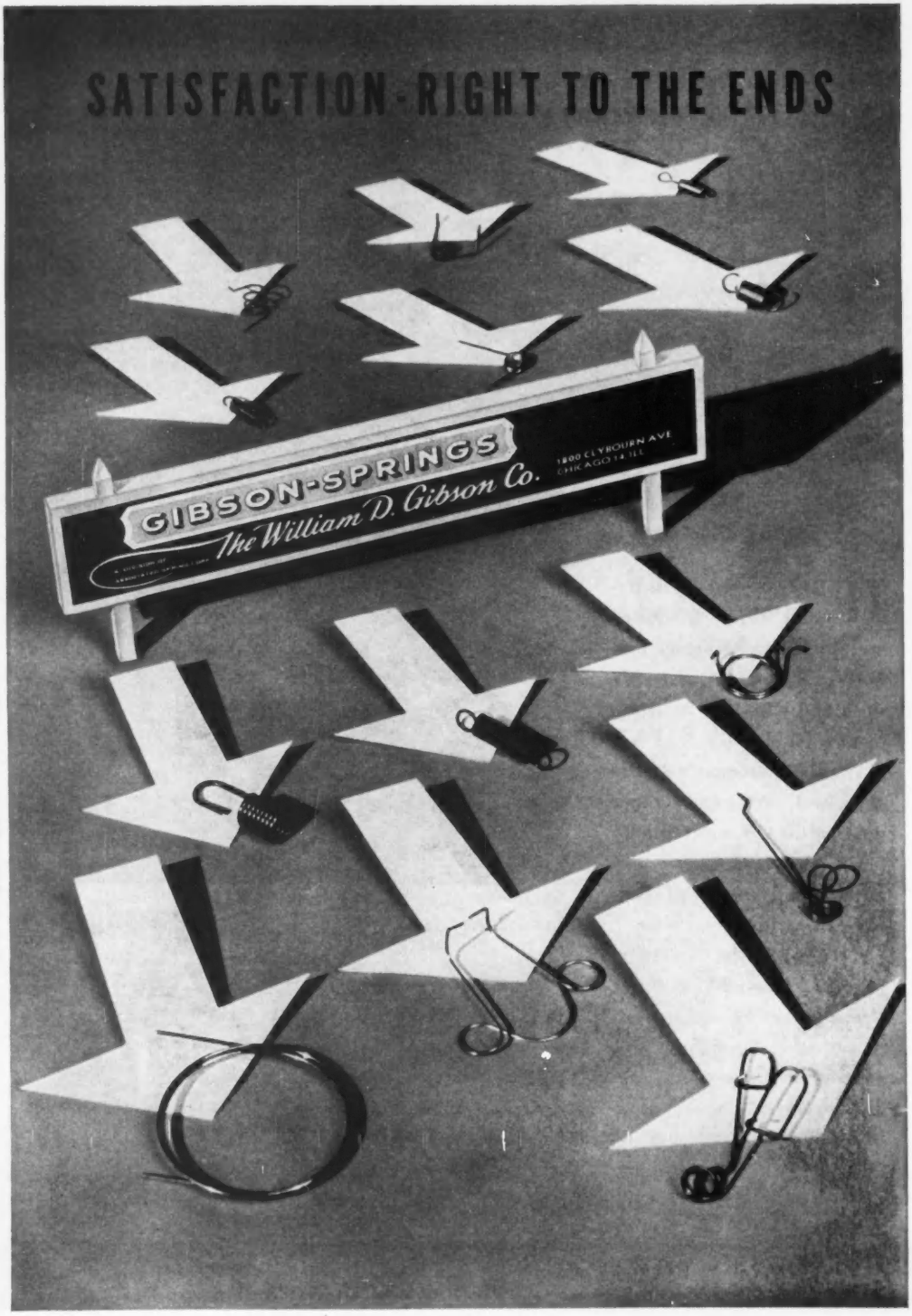
HERE'S the way Hyatt Hy-Load Roller Bearings are applied to planetary pinions to speed up assembly work and eliminate fussy adjustments.

The Heil Company's 2C800 two wheel tractor and scraper unit we are illustrating to typify the design and performance advantages of Hyatt Roller Bearings.

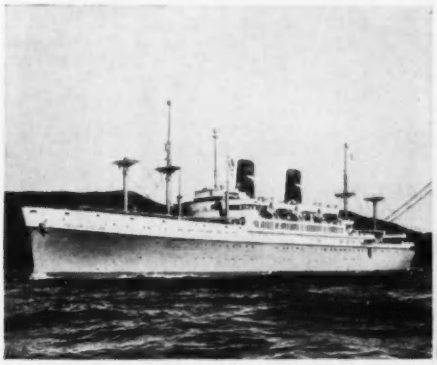
Along with these pinion applications other Hyatt Roller Bearings . . . forty-eight in all . . . are used throughout this entire Heil tractor and scraper unit to insure further construction advantages and dependable, trouble-free operation for the life of the equipment.

All of which proves that it pays to build Hyatts into the machines you manufacture or look for them in the equipment you buy. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

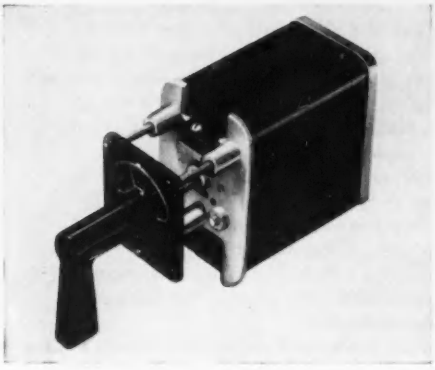
HYATT ROLLER BEARINGS


SATISFACTION-RIGHT TO THE ENDS
GIBSON-SPRINGS
The William D. Gibson Co.
1800 CLYBOURN AVE
CHICAGO 14, ILL.

Mighty midget controls cooling of giant ship propulsion motors



American President Lines' "President Cleveland"



Another job easily done with the SB-1 CONTROL AND TRANSFER SWITCH

Little bigger than a fist, a mighty midget of a switch controls the blower motor for ventilating each of the two 10,000-hp synchronous motors that drive the S.S. "President Cleveland." Similar switches select voltmeter readings, control d-c power input for switchboards, select stator temperature readings, and help control the ship's dynamic braking system and voltage regulator.

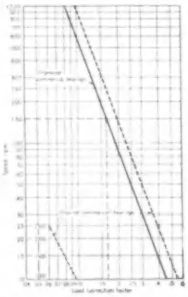
By varying cam and finger arrangements and the number of stages, design engineers already have utilized the General Electric SB-1 for over 10,000 circuit-sequence control combinations with capacities up to 20 amperes at 600 volts a-c or d-c. There's a standard SB-1 for most jobs. If a standard can't satisfy, we'll build what you want from standard parts of the basic design.

A variety of switch handles and water-tight, dust-tight, oil-immersed, fabricated-metal or explosion-proof housings are available. For further details see your G-E sales representative or write for Bulletin GEA-4746. *Apparatus Dept., Section 856-75, General Electric Company, Schenectady 5, N. Y.*

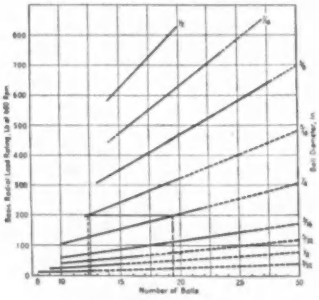
856-75

GENERAL ELECTRIC

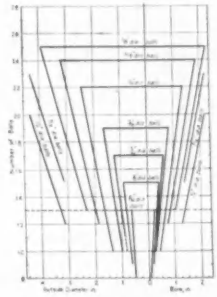
How to Reduce Your Bearing Costs 35 to 85%



1. SPEED-LOAD CORRECTION: Find equivalent load rating of unground bearing by applying correction factors obtained from this chart. This is necessary since "Commercial" bearings are rated at 150 r.p.m.; correction factor is 1.65; equivalent load at 600 r.p.m. is 200 pounds.



2. LOAD RATING: Using equivalent load rating, find from graph above number of balls and diameter of balls required to handle equivalent load. For previous example, this demands 13 balls 5/16 in. in diameter, or 20 balls of ¼ in. in diameter.



3. BORE AND DIAMETER: Determine minimum outside diameter and maximum bore for selected bearings from this chart. The 13-ball 5/16 in. diameter ball bearing o.d. is 2 in., bore is 1-3/16 in. The 20-ball ¼ in. diameter ball bearing o.d. is 2¼ in., bore is 1¼ in.

One way to cut costs—without impairing product quality—is to take a close look at the possibilities of "Commercial" ball bearings in your design. Expensive precision bearings, made to extreme tolerances, are costly and often unnecessary for average anti-friction applications.

Schatz "Commercial" bearings, although low in cost, have, unless otherwise specified, carburized, hardened and tempered, high-grade steel races. High quality balls are used.

These bearings are available in metric dimensions; can be furnished with set screws, with seals and Alemite fittings, with hex bores, with inner and outer rings having various shaped grooves, threaded studs and other modifications. Composition treads of plastic or rubber can be specified.

A high-performance Schatz "Commercial" can economically replace bushings or plain sleeve bearings; eliminate costly machining and assembly time; improve product efficiency. It will pay you to look into Schatz possibilities in your product.

FOR EXAMPLE:

A Schatz bearing eliminated assembly rejects in a textile machine operating at 2,500 r.p.m. under a 20-pound load. The specially-designed "Commercial" had a split inner race and flanged outer race that replaced a slotted washer spot welded to a standard bearing. Result: one operation was cut out, and assembly rejects due to heat-distortion were completely eliminated.

An adjustable-width "Commercial" bearing designed by Schatz engineers helped an office-machine maker control bearing end-play on a typewriter carriage operating at 600 r.p.m. under a 12-pound load. The bearing is easy to mount, provides good rigidity. Its use simplified the machine design considerably.

Cost of "Commercial" bearings *decreases* in almost direct proportion to size; in high-precision bearings, cost *increases* as bore decreases.

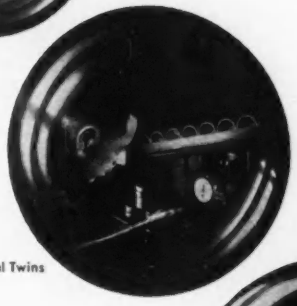
IF YOU HAVE A FRICTION PROBLEM, LET SCHATZ ENGINEERS DESIGN IT AWAY

THESE AND OTHER TABLES showing correct size and type "Commercial" Ball Bearings for various speed and loading conditions, and graphs for estimating bearing life, are included in "Construction and Characteristics of Low-Cost Ball Bearings." This technical booklet also discusses modifications that can be made for special design, assembly and operating conditions. Catalog No. 11 gives data on the complete Schatz "Commercial" line. Write for your copies today.

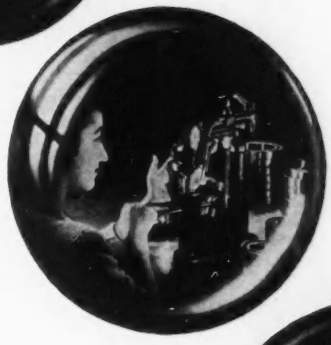
SCHATZ
"Commercial"
BALL BEARINGS

THE SCHATZ MANUFACTURING COMPANY · 6758 FAIRVIEW AVENUE, POUGHKEEPSIE, N. Y.

Taking Stock of Steel Stock

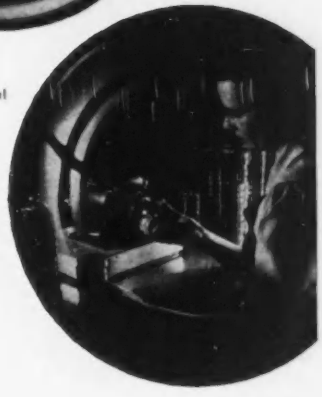


Identical Twins



Watching for Wobble

Dividing the Plus and Minus



Quiet, please!

Precision + Patience = Federal Ball Bearings

Before any Federal Ball Bearing starts on its way to industry's assembly lines it has gone the route of over 100 production, inspection and cleaning operations.

It all adds up to quiet running and smooth, frictionless operation. That's why, *wherever tolerances are tight*, specify Federal Ball Bearings...in *any* range or size.

Our 260-page Catalog "K" describes the complete line. Also write for a copy of our latest Ball Bearing Conversion Tables which contain complete up-to-date interchange information.

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, NEW YORK

Makers of Fine Ball Bearings

FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

Quality since 1908

Seeking help in fabricating tubular parts?

If you are now called upon to supply tubular parts fabricated of non-ferrous tube, look in on the specialized facilities available to you here at Wolverine.

Regardless of how you may be set up for producing the parts you contemplate, you'll find it a definite advantage to consider Wolverine's skill and knowledge of fabrication.

You have at your command over three decades of tube-manufacturing and related fabrication experience that can help you immeasurably.

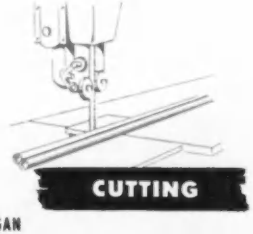
We can supply the complete tubular parts or show you the most efficient ways of fabricating the parts in your own plant.

The illustrations here suggest only a few of the many operations that we are particularly equipped to render assistance to you.

WOLVERINE TUBE DIVISION

Calumet and Hecla Consolidated Copper Company
INCORPORATED

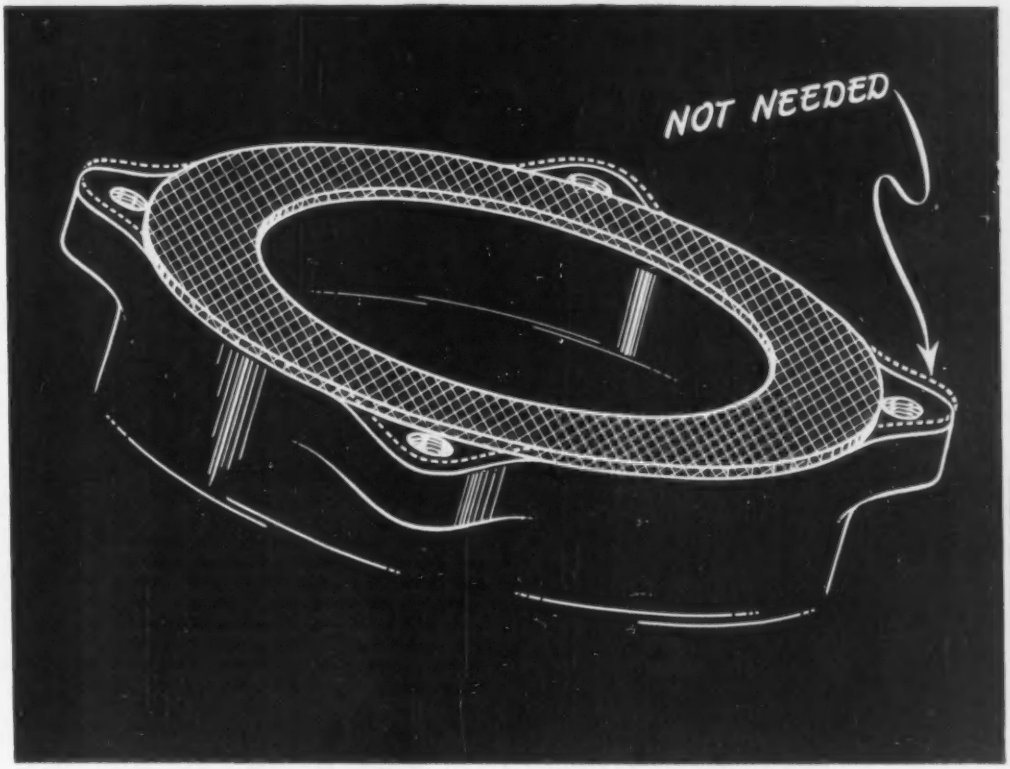
Manufacturers of seamless, non-ferrous tubing



WOLVERINE TUBE DIVISION, 1415 CENTRAL AVENUE, DETROIT 9, MICHIGAN

PLANTS IN DETROIT AND DECATUR, ALA.
Sales Offices in Principal Cities

Export Department, 13th E. 40th St., New York 16, N. Y.



Simplifying gaskets for military applications

It is always desirable to keep gasket shapes simple. In military applications, such simplicity may offer especially important benefits. For example, manufacturing time may be reduced or gasket delivery may be improved. In some cases both advantages may result.

The drawing above shows an instance where a compressible gasket material permitted removal of gasket ears. These ears, used simply to hold the gasket in position, could be eliminated because it was not necessary to seal around the bolts or prevent moisture from accumulating between the flanges.

By making the O.D. of this gasket tangent to the edge of the holes, accurate positioning is assured. The resulting unrestrained gasket remains firmly seated because it is cut from one of Armstrong's Cork-and-Rubber Compositions, a material that deforms in the direction of the load without appreciable sideflow. Such a compressible gasket has little tendency to creep. Even on flanges covered with oil, its cork-dotted surface resists slippage. In addition, its excellent resistance to fatigue makes it ideal where field conditions make gasket re-use necessary or desirable.

Another way in which Armstrong's Cork-and-Rubber Compositions prove effective is in overcoming supply difficulties caused by joint designs that call for special-section molded parts. Often, these parts can be replaced with square or rectangular-section compressible gaskets. Being truly compressible, such gaskets will deform sufficiently to seal tightly.

Truly compressible gaskets often speed production in other ways. They may be lathe-cut or die-cut to shape, thus eliminating the time and expense of mold-making. Mirror finishes, too, usually are not necessary because compressible gaskets permit wider tolerances.

There are standard Armstrong Cork-and-Rubber Compositions designed to meet all grades of the general military specifications covering this type of gasket materials. For information on new gasketing materials being developed to meet special military requirements, consult your Armstrong representative.

See Armstrong's Gasket Materials manual in Sweet's file for product designers for other design suggestions covering both joints and gaskets. For a personal copy of this manual, write to the Armstrong Cork Company, Gaskets and Packings Dept., 7104 Arch St., Lancaster, Penna.

ARMSTRONG'S *Gasket Materials*

DIE CASTING

...if you want to cut corners, speed production, lower costs

CASE HISTORIES FROM MT. VERNON FILES

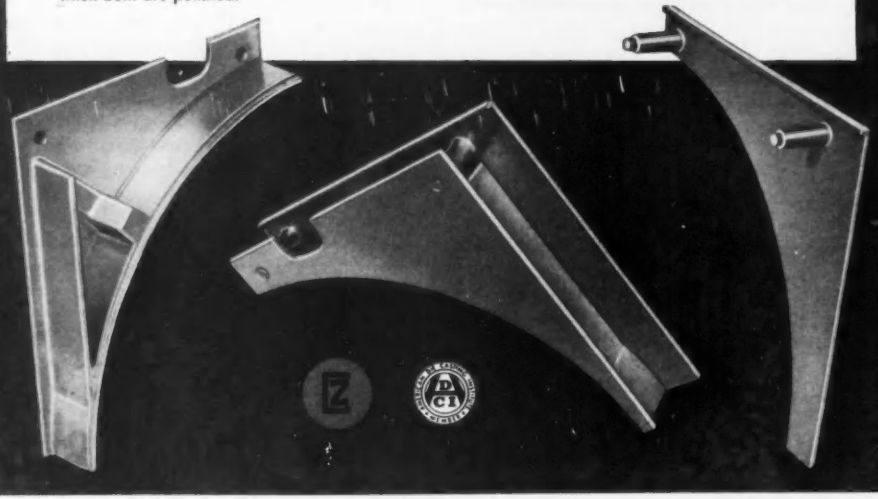
Yes, die casting means **savings** — in time, effort, and raw materials.

Here's a case in point: Aluminum die castings serve as corner pieces on this sliding type bus sash, to fill the square openings in the bus body and round out the inner sash frame for better appearance. Die casting is employed to make the pieces, because ***no other method*** of manufacturing these corner inserts can produce them so inexpensively — or so well.

Look at these inserts. Specially designed to facilitate sash assembly, each consists of two parts that lock together by means of studs. Says Transportation Sash Company, Inc., makers of this type sash for Mack C-50 buses: "These die castings are eminently satisfactory. No machining is required, and the finished corner pieces match the aluminum extrusions used in the sash when both are polished."

Here's economy without sacrifice of appearance or strength! If **you** haven't already considered the cost-cutting possibilities offered by die casting, why not consult with us? We have helped a host of manufacturers "corner" the difficulties in their production problems, and get the answers to increased output and better products— ***at less cost.***

MT. VERNON
DIE CASTING CORP.
MT VERNON NEW YORK



Farval pays for itself quickly, many times over

...saving oiling labor
...saving lubricant
...saving bearing expense
...saving production time

WITH Farval you lubricate your machinery or equipment mechanically. Farval does the job quickly and dependably.

Any type of bearing surface, enclosed or open, can be Farval-lubricated with grease or oil. Measured charges of lubricant are metered to each bearing through the unique Dualine Valve, delivered under pressure from a central reservoir, either by a manually operated pump or one actuated by an automatic time-clock mechanism.

Farval is not a new idea. It has proved its value in service over a 23-year period, protecting millions of bearings in every phase of industry—in manufacturing plants, mining and quarrying operations, transportation—wherever there are bearings that have to be lubricated. Thousands of installations on mills, presses, conveyors, cranes, engines and other industrial equipment provide records of money saved. Savings take four forms:

1. Labor saving—Farval eliminates hand oilers. Minimum attention only is required—to inspect system, refill lubricant reservoirs, etc.

2. Lubricant saving—Correct amounts are used without waste, frequently reducing oil or grease consumption as much as 75%.

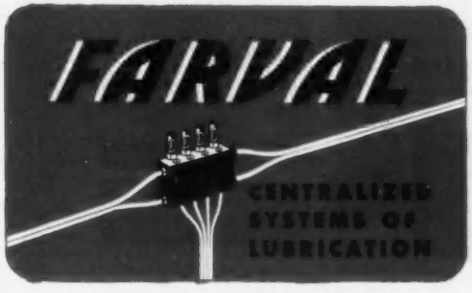
3. Bearing expense saving—No more burned out or damaged bearings with Farval protection. Expense of replacement eliminated.

4. Production time saving—Farval lubricates while equipment is running. No shutting down to oil. No taking a machine out of production to repair or replace bearings.

In short, savings are so positive that you soon recover the entire cost of a Farval system—and savings continue as extra dividends.

If you want figures on savings possible with Farval on the types of machines you operate, just write us. Tell us what equipment you have and ask for Bulletin 25. The Farval Corporation, 3279 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.



FARVAL—*Studies in Centralized Lubrication* No. 122

It pays to use your custom molder's know-how

and proof is clear on a million TV screens

No. 26 in a Series on Plastics Skill at Work...

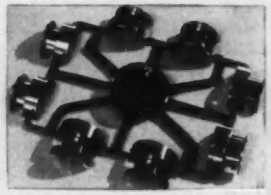
PROJECT: Deflecting yoke spool for TV picture tubes

CUSTOMER: RCA Victor Division, Radio Corporation of America

MOLDER: Shaw Insulator Co.

MATERIAL: Durez black general-purpose phenolic plastic

ONE RIM OF SPOOL serves as terminal board for 8 terminals, and supports small resistors and capacitors. Molded-in interlocking projections facilitate assembly of the 2-piece spools. The use of molded half-spools made it possible to replace approximately eight parts formerly used.



EIGHT HALF-SPOOLS of Durez phenolic per "shot" are produced by custom molder. These meet rigid requirements including very thin walls, dimensional exactness, freedom from warping, high insulating value, and resistance to heat.

● "Riding" the neck of the modern cathode-ray TV picture tube is a deflecting yoke . . . deflecting coils and magnetic core . . . which guides the electron stream that is transformed into glowing video pictures on the screen face of the tube.

The yoke is the extremely critical component that determines the uniform brightness of the picture, its symmetry, and freedom from exaggeration and distortion. Its elements must be supported in an exact relationship, and insulated to withstand high voltage.

This is the job of the spool molded of Durez phenolic plastic . . . another example of the custom molder's know-how in meeting severe requirements with parts that simplify assembly. Supplanting a stapled cardboard assembly, the molded Durez spools have contributed to the dramatic growth of the television industry by making possible a distinct improvement in a vital component in more than a million sets.

Your custom molder's know-how, plus the famous versatility of Durez phenolics, is a hard-to-beat team when you want the best value you can get for your plastics dollar.

Ready with skilled counsel is your Durez technician, backed by over 25 years of specialized experience.

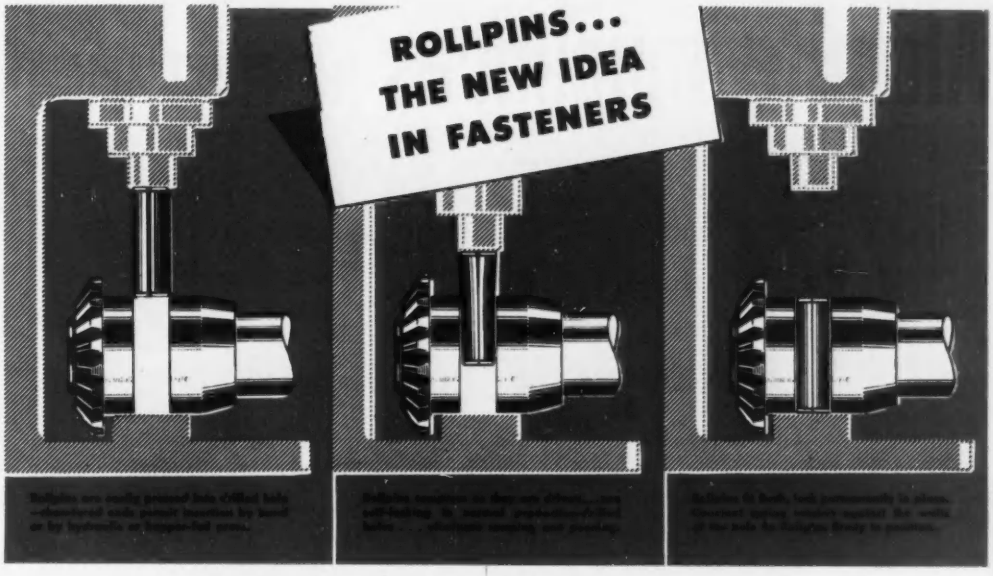
Our monthly "Durez Plastics News" will keep you abreast of industry's uses of Durez. Write, on office letterhead, to Durez Plastics & Chemicals, Inc., 2004 Walck Road, North Tonawanda, N. Y.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB



How to cut pinning costs with Rollpin self-locking fasteners

Investigate now the real production savings on every type of job involving pinning. Rollpin self-locking fasteners are ready to help you do away with expensive reaming, peening, machining and threading operations by replacing taper pins, grooved pins, rivets and set-screws.

Quickly inserted into standard drilled holes, Rollpins are there to stay—vibration-proof until removed with a pin punch . . . and Rollpins can be *re-inserted* with a hammer! A neat, clean, self-locking assembly is provided; and Rollpins exceed the shear strength of a cold rolled pin of equal diameter.

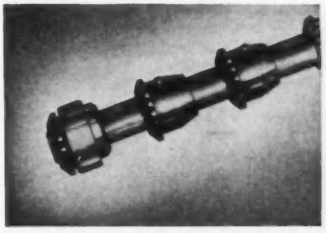
Slashing assembly time, inspiring new product designs, simplifying old fastening procedures, Rollpins are now helping cut manufacturing costs as steel fastening pins holding pulleys and gears to shafts, as pivot or hinge pins, clevis pins, cotter pins, shafts, and locating dowels.

Get the latest information about your application. Write to Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.

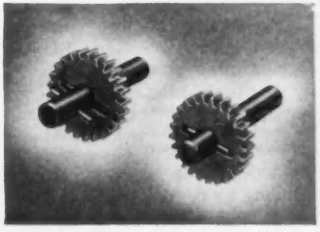
ROLLPIN TRADEMARK
A PRODUCT OF

ESNA TRADE MARK

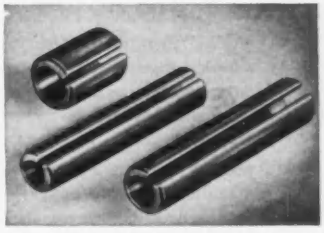
ELASTIC STOP NUT CORPORATION OF AMERICA



More than 20 gears are quickly Rollpinned to gear train shaft used on farm equipment. Assembly time was cut . . . field service problems were solved because Rollpins drive out readily.



Rollpin is used as a self-retained pin in shaft . . . which is press-fitted into recess molded into sintered gear. Rollpin's unusual shear strength makes it ideal for this use.



Rollpins are supplied to specified lengths with chamfered ends. They are available from stock in a wide range of lengths in diameters from 5/64" to ½" in Carbon and Stainless Steels.

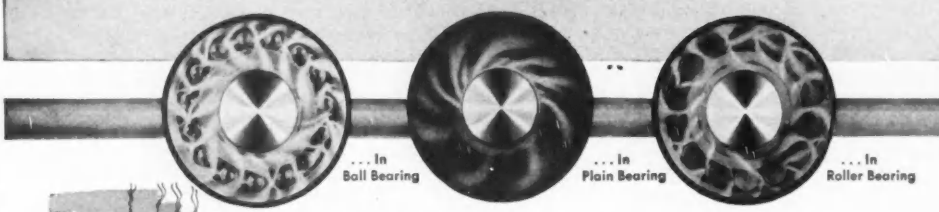
Alemite Announces THE MOST AMAZING

ALEMITE OIL-MIST

AUTOMATIC LUBRICATION SYSTEM

Unbelievably simple system atomizes oil into mist, circulates it through tubing to bearings. Bathes all bearing surfaces with fresh, clean, cool oil film. Uniformly maintains oil film on all sliding, rubbing, rolling parts regardless of variations in load, temperature or speed! No "peaks and valleys" of lubrication.

Fully automatic—eliminates waste and the uncertainties of the "human element." Extends bearing life as much as 17½ times. Seals bearings against dirt and abrasives. Cuts oil consumption as much as 90%. Greatly reduces the number of oils needed.



Here is lubricating progress so major—so far-reaching—as to command the interest of *every* executive concerned with industrial lubrication practices and costs.

You'll marvel that a system so simple—without any moving parts—can bring such a revolutionary change in the lubrication of machinery.

The Alemite Oil-Mist System requires only two simple settings—to control the amount of air pressure, and to regulate the density of the Oil-Mist. Once set, they require no further attention.

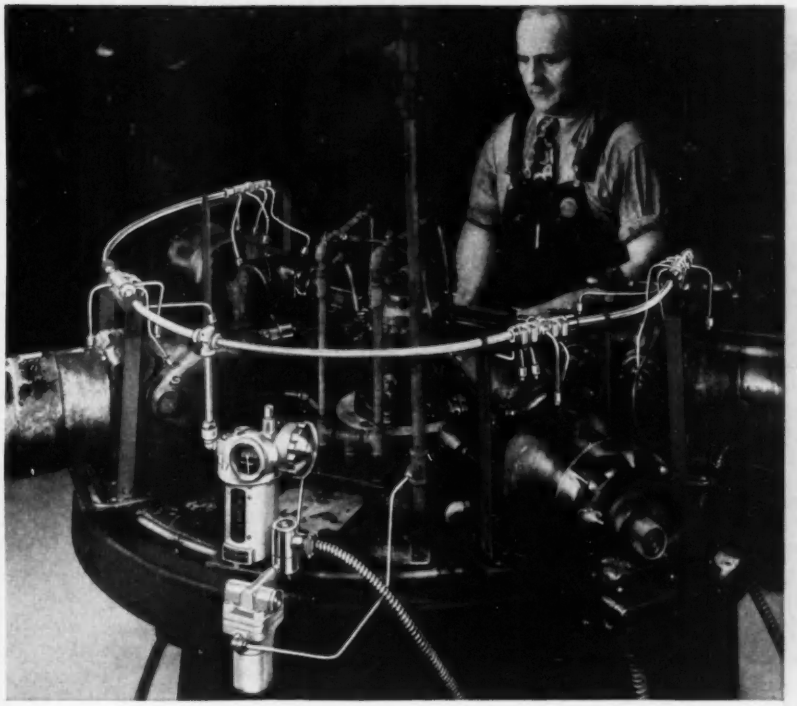
This great new Alemite Oil-Mist System has been proved by plant installations on a wide variety of machines in many industries including steel, coal, food processing, chemicals, metalworking, textiles and woodworking. The results are spectacular—in reduced lubrication costs, reduced maintenance costs, reduced service, reduced "down-time."

Desk-Top Demonstration,

No Obligation—Mail Coupon at Right

The handy coupon attached to your Company letterhead will bring a trained Alemite Lubrication Representative to your office. In a brief yet thorough Desk-Top Demonstration he will answer questions and tell you how Alemite Oil-Mist can provide more efficient lubrication at lower cost than you ever thought possible. Clip and mail the coupon today—to Alemite, Division of Stewart-Warner, 1850 Diversey Parkway, Chicago, Ill.

AUTOMATIC LUBRICATION SYSTEM EVER INVENTED



Here is an example of the many kinds of mechanical motions that can be lubricated by an Alemite Oil-Mist System, *using one oil.* On this automatic drilling machine Alemite Oil-Mist is lubricating 20 points, including cam, quill, worm and gear, reduction gear, gear and rack, gear train, plain and ball bearings. With Alemite Oil-Mist, this machine consumes only 10 oz. of oil during an 80-hour work week. System draws less than ONE cu. ft. of air per minute at 10 psi.

← OIL MIST ← OIL MIST

8 Advantages of the Alemite Oil-Mist System

1. Continuous Lubrication

Constantly deposits a fresh, clean film of oil on all surfaces of all bearings in the system.

2. Fully Automatic Lubrication

Eliminates the uncertainties of the "human element." (Refilling the reservoir is the only periodic service required.)

3. Elimination of Guesswork

Every bearing picks up only as much Oil-Mist as it needs. No bearing can be overlooked. None gets over-lubricated.

4. Reduction of Bearing Temperatures

Oil-Mist acts as bearing coolant, can lower bearing temperatures as much as 20°F.

5. Reduction of Types of Oil

Oil-Mist greatly reduces the number of oils that must be stocked, handled, and applied.

6. Elimination of "Down-Time"

All bearings in the system are constantly lubricated while the machine continues to produce.

7. Extension of Bearing Life

Oil-Mist multiplies the life of bearings many times. The life of grinding machine bearings has been extended from 400 to 7,000 hours.

8. Consumption of Oil Cut 90%

The Oil-Mist System usually consumes approximately 1/10 the amount consumed by any other oiling method.

Alemite OIL-MIST Lubrication

Another Product of STEWART WARNER

Mail this coupon today!

Alemite, Division of Stewart-Warner, Dept. T-41
1850 Diversey Parkway, Chicago 14, Ill.

☐ Please have your Alemite Lubrication Representative arrange a desk-top demonstration of Oil-Mist. This entails no cost or obligation on my part.

☐ Please send me information about Oil-Mist by mail.

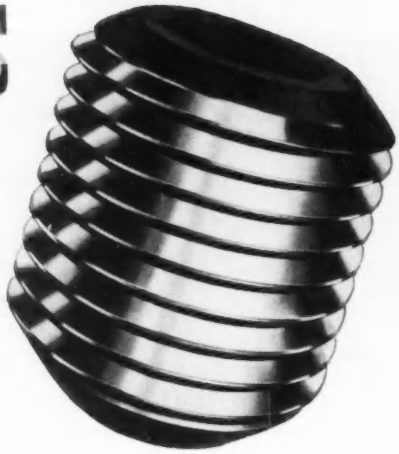
My name .....

Position .....

Company (leave blank if letterhead attached) .....

OPERATION :

PROGRESS



Deep-grained in America's makeup is the restless urge to make that which is good—*better!* It is at the root of America's soaring output of the weapons of war. It is the hard core of our unmatched peacetime productivity.

Parker-Kalon's several contributions to "Operation PROGRESS" are notable. The story behind P-K* Ground Thread Socket Set Screws is a typical case in point.

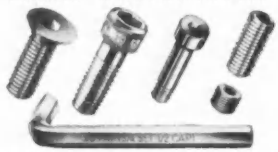
For decades, everyone was satisfied with conventionally threaded screws. Then, engineers of the Parker-Kalon organization took a long, hard look—saw the possibility of applying thread-grinding to mass production of Socket Set Screws, something previously reserved only for screws of instrument precision produced without regard for high cost.

The result . . . P-K Ground Thread Set Screws . . . free of nicks, burrs and tool marks . . . every screw a dependable Class 3 Fit. You can *see* and feel the difference . . . see why they were quickly recognized as the best buy in Socket Set Screws.

P-K production continues 'round-the-clock to furnish the tremendous quantities wanted today for more fine products than ever before. For DO or other assemblies, set your standards by famous P-K quality. Parker-Kalon Corporation, 200 Varick Street, New York 14, N. Y.

P-K
TRADE MARK
REG. U.S. PAT. OFF.

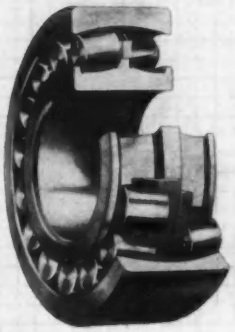
FOR ANY TYPE OF SOCKET SCREW
REMEMBER—IF IT'S P-K . . . IT'S O.K.®



Flat Head Socket Cap Screws • Size-marked Socket Head Cap Screws
Stripper Bolts • Ground Thread Socket Set Screws • Pipe Plugs • Hex Keys
Available Through Accredited Distributors

PARKER-KALON*
cold-forged
SOCKET SCREWS

*TRADE MARKS REG. U.S. PAT. OFF.



when the drilling is tough

TORRINGTON SPHERICAL ROLLER BEARINGS

Wilson Manufacturing Company backs up drill bits with smoother power, easier control and rugged construction in its Giant Remote Control Rigs.

Torrington Spherical Roller Bearings are used in many applications in Wilson rigs. Despite heavy loads Spherical Roller Bearings deliver power efficiently without developing binding stresses under shaft deflection. Accuracy of contact between rollers and races provides high capacity, insures stamina and low maintenance on exacting drilling schedules.

Automatic self-alignment, high load capacity and precision operation are features of Spherical Roller Bearings that can help you improve performance of your equipment. Call in a Torrington engineer to help you work out details of design and application.

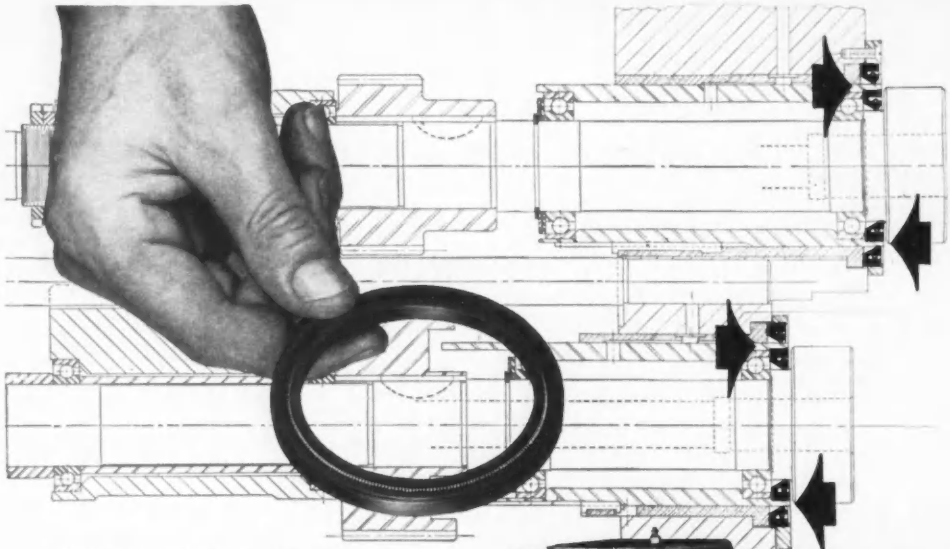
THE TORRINGTON COMPANY

South Bend 21, Ind. • Torrington, Conn.

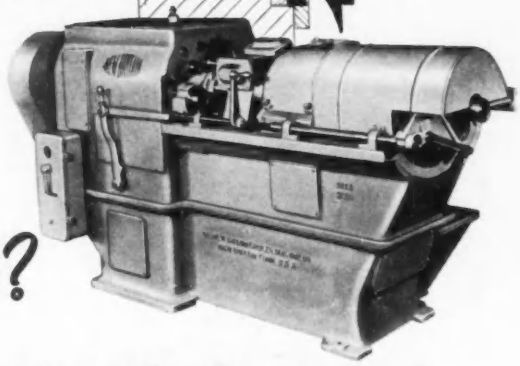
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON SPHERICAL ROLLER BEARINGS

SPHERICAL ROLLER
TAPERED ROLLER
STRAIGHT ROLLER
NEEDLE
BALL
NEEDLE ROLLERS



Blueprint shows four locations where Clipper Seals help maintain smooth running, accurate operation of the New Britain Model 23A Chucking Machine. Photograph is of the complete machine.



Is this your OIL SEAL problem?

New Britain solved it with Clipper Seals

WHEN the New Britain Machine Company, New Britain, Conn., designed their model 23A Automatic Chucking Machine, they were planning a machine tool that would maintain its precision under long, hard service conditions.

This called for tough, precision-made components—of which Clipper Seals are an outstanding example. The compact design of these seals and their ability to do a highly efficient job of retaining lubricants, and sealing against cutting oils and abrasives, were important factors in New Britain's choice of Clipper Seals.

Clipper Seals won out on other counts, too. It was found that they decidedly reduce friction and wear, assuring trouble-free operation and long service life at high shaft speeds. In addition, Clipper Seals supplied the answer to easy installation because the tough, dense heel provides just the right amount of rigidity for a press fit in the cavity . . . while the flexible lip, held in light but positive contact with the shaft by an especially designed garter spring, provides effective sealing at all times.

These precision-moulded oil seals—made in both split and endless types—are available in a wide variety of designs, and in heel and lip compositions to meet practically any sealing requirement. For details, write for Brochure PK-46A. Address Johns-Manville, Box 290, New York 16, N. Y.

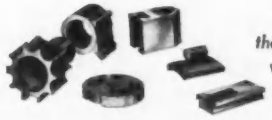
JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CLIPPER SEALS

OILITE may relieve your shortage of critical materials

Particularly in mass-production units of small and medium size, Oilite finished machine parts and bearings can be made to your design in a broad range of ferrous and nonferrous metals and alloys, except as limited by government control. Moreover, Oilite products of ferrous base may serve excellently instead of scarce nonferrous units or as replacements for steel and castings.

When you employ Oilite you also obtain the benefits of more than 20 years' engineering, research, and production experience in powder metallurgy, together with the service of field engineers throughout the United States and Canada.



You are invited to contact the field engineer in your district or write the home office regarding the application to your needs of Oilite products.

AMPLEX MANUFACTURING COMPANY

Subsidiary of Chrysler Corporation

DETROIT 31, MICHIGAN

Field Engineers and Supply Depots in Principal U. S. and Canadian Cities

OILITE PRODUCTS

Heavy duty, oil-cushioned, self-lubricating bearings and finished machine parts in ferrous and nonferrous metals and alloys. Permanent filters. Friction units. Self-lubricating cored and bar stock.

A Note to Executives

Oilite is an effective replacement, not a mere substitute

In the last decade, more and more executives have become "Oilite minded" because the advantages are many. To meet the current situation, many of our customers have changed their specifications to replace strategic copper and tin with products of iron powder or iron powder alloys. Others are replacing iron castings, steel and aluminum with similar Oilite products.

Also of importance to executives, under conditions of urgency, are the wide adaptability, the speed of delivery, and the economy of cost, time and manpower which result from the use of Oilite finished machine parts, made from metal powders.

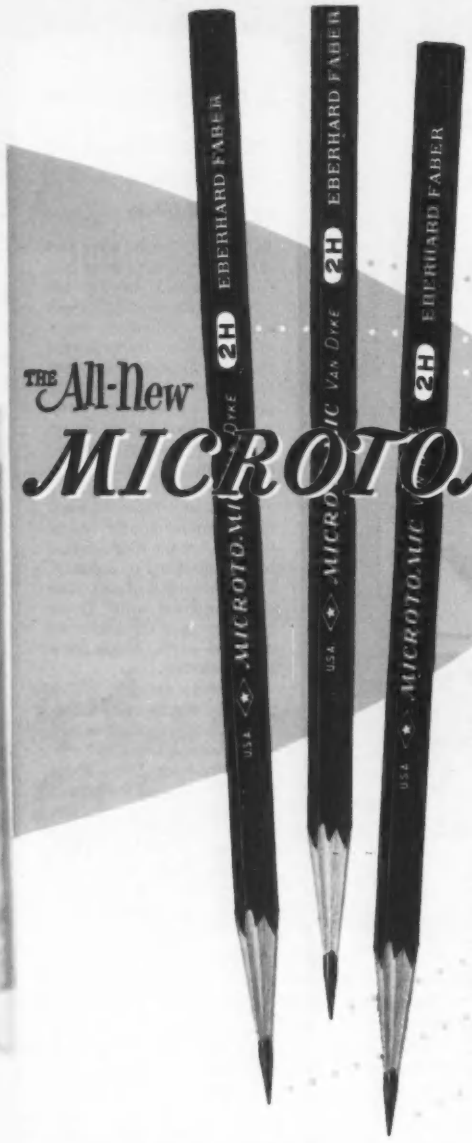
Intricate designs, which normally require many different machining operations, can be produced quickly and economically from Oilite. There is great freedom of design and frequently two or more parts can be combined in a single Oilite unit. Oilite eliminates up to 24 machining operations.

Delivered ready for assembly, Oilite parts save the time and investment required to tool up by standard methods. It is not unusual to be in production on a complex Oilite part within a few weeks, as compared to a possible 18-month delivery of machine tools. Trained manpower is thus released for other urgent needs.

Oilite is not a substitute. It is metallurgy's answer to the need for a new material. It may solve your problem.

President

OILITE
PRODUCTS



WHEN THEY *Say* 2H

The All-New MICROTOMIC

...THEY *Mean* 2H!

If you have ever put down one 2H pencil . . . picked up another . . . and found it softer or harder than the first . . . it's time you discovered the meaning of absolute MICROTOMIC uniformity. Try the '3-Against-3' Test now! Newly developed quality controls keep all new MICROTOMIC leads of each degree identical!

EYE, TIME, WORK SAVERS

New Dusk Gray Color, choice of hundreds of draftsmen asked to pick most desirable color for a new drawing pencil. New 'bull's-eye' degree marking on 3 sides—makes the right pencil easier to find.

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Clearer Prints, because MICROTOMIC new Hi-Density lines are exceptionally opaque to the actinic rays of high-speed 'printers'. Result... *dead-white* lines, without feathering or blurry edges!

free! TRY THE "3-against-3" test

Mail the coupon for 3 FREE New MICROTOMIC Drawing Pencils. Test them for uniformity against your present pencils. *You can't miss the difference...mail now!*

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37 GREENPOINT AVENUE, BROOKLYN 22, N. Y.

Send me 3 New MICROTOMIC Drawing Pencils FREE. I'll test their uniformity against my present pencils. Degree..... *(specify only one)*

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City..... *State*.....

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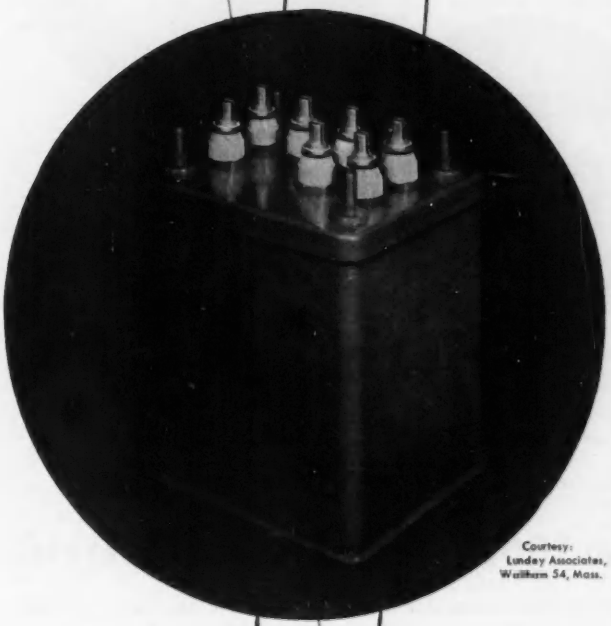
TRADE MARKS REG. U. S. PAT. OFF.

WEATHER RESISTANCE

SUNLIGHT RESISTANCE

OIL RESISTANCE

These properties of neoprene make a better TRANSFORMER for the TROPICS



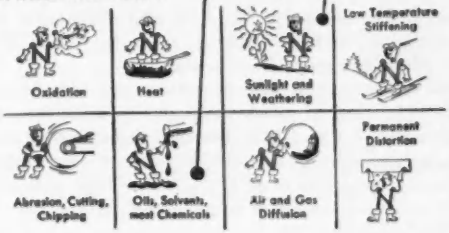
Courtesy: Lundey Associates, Waltham 54, Mass.

Moisture, held by tropical fungus growths, was causing rapid failure of vital military transformers. A solution to the problem was found in the unusual properties of neoprene. A transformer was developed in which the terminals were designed to provide a hermetic seal by using resilient flanged inserts and cushioning washers of Du Pont neoprene.

The transformer's design called for neoprene because it can be specially compounded to resist fungus attack. And neoprene is unequaled in its ability to withstand sunlight and weather. Even after long exposure it doesn't check or crack . . . retains high tensile strength. What's more, neoprene's oil resistance enables it to stand up under constant contact with the insulating oil used in a transformer of this type.

These properties of neoprene, together with all its other characteristics, explain why foremost designers and engineers are specifying its use in critical rubber products. Rubber goods manufacturers can formulate neoprene with a combination of properties to meet your most exacting requirements.

PROPERLY COMPOUNDED NEOPRENE WILL RESIST:



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Full of interesting stories. New, unusual applications of neoprene to build new products . . . improve old products . . . reduce maintenance costs.

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Rubber Chemicals Div. B-4, Wilmington 98, Del.
Please send me free issues of **The Neoprene Notebook.**

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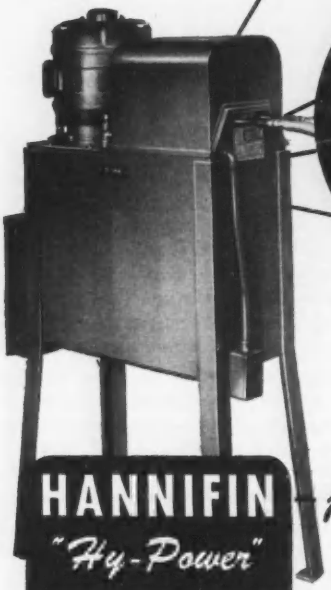
With these Tools One Man Can Do More Work!

PUNCHING—7½-ton Hannifin "Hy-Power" Portable Punch used in the assembly of light gauge sheet metal structures.

RIVETING—Fabricating steel furnace sections with 25-ton Hannifin "Hy-Power" Portable Hydraulic Riveter.

RIVETING—35-Ton "Hy-Power" Portable Riveter used in assembling heavy truck trailer frames.

PRESSING—7½-Ton Portable "Hy-Power" Press used in pressing timing gears on automobile engine crankshafts on conveyor assembly lines.



HANNIFIN "Hy-Power" HYDRAULIC Power Units

"Hy-Power Hydraulics"—ASK for a copy of this 28 page illustrated Bulletin No. 150 for Tool Designers and Production Engineers.

plus TOOLS that anyone can operate!

HERE is a combination that can't be beat! Hannifin "Hy-Power" hydraulic units quickly pay for themselves in even small production shops. In any plant, they enable a man to handle almost unbelievably large volumes of work with a minimum outlay for equipment and floor space. A most important advantage is that anyone can operate them and, without any special skill or experience, turn out perfect work hour after hour at peak speed. Physical effort needed to handle balanced tools is negligible. Work performed by different operators is always uniform.

Hannifin supplies everything you need—complete units designed to meet your particular requirements, or power units and cylinders for use in machines of your own design. Today, in thousands of installations throughout the world, production engineers and tool designers are using Hannifin "Hy-Power" Hydraulic equipment as the key to better, faster production and lower costs for an almost unlimited range of applications! You, too, can benefit from this equipment. *For complete information, see your local Hannifin representative, or write.*

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PNEUMATIC PRESSES • HYDRAULIC RIVETERS • AIR CONTROL VALVES

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Syntech* rubber-covered O. D. Oil Seals that have a proved-performance record in rugged Off-Highway Vehicles

Illustration courtesy of Willys-Overland Motors, Inc.

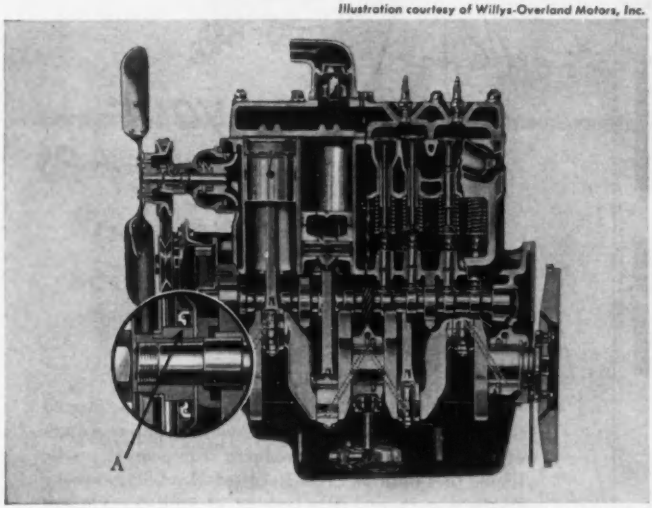

Figure 1. Section through "L-Head" engine. Enlargement shows position of National Oil Seal (A)

Vehicles designed for off-highway use must be built to take the roughest treatment under the most gruelling conditions. In such applications the oil seals in all positions meet their most exacting tests for dependability. A case in point is the front main crankshaft seal used on the engine of the Universal Jeep, built by Willys-Overland, which has been put through every manner of rough treatment.

The illustration (Fig. 1) is a section through the Universal Jeep L-Head "Go-Devil" Engine, showing, close up, the location of the oil seal (A) which retains the crankcase lubricant. The compactness of the entire engine places extreme limitations on the size of this oil seal. Efficiency and dependability are extremely important in this application because the equipment must be capable of dependable operation over unpaved, rugged terrain. The oil seal may be heavily flooded going down steep inclines and oil-starved going up. Furthermore, when in the field proper servicing may be neglected for long periods.

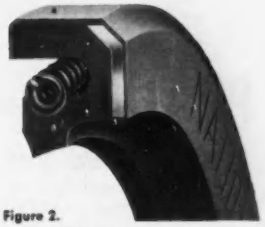

Figure 2.
Cross-section of National Rubber-covered Oil Seal

On applications such as this, National Syntech rubber-covered sealing units are a close approach to the ideal. Essentially these seals consist of a sealing member which is bonded to a steel structure at the time of molding. This method of fabrication makes it possible to produce a seal possessing high performance capabilities but requiring the minimum space.

The section drawing (Fig. 2) is of one of the seals being used on the Universal Jeep built by Willys-Overland. Despite its compactness this seal incorporates the basic, limited-contact, spring-tensioned lip design used on many larger National Oil Seals. This design, operating in well-lubricated areas, provides "zero-leakage" performance with the minimum of drag. The rubber O.D. forms an effective seal around the outer periphery. Basically it is a slightly altered regular National 350,000 series seal.

National engineers will be happy to cooperate with you in solving your sealing problem. Many times standard designs can be utilized with resulting savings in tooling costs which are sometimes required on special designs.

"Let Your Decision be Based on Precision"

NATIONAL OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City, Calif.; Downey (Los Angeles County), Calif.; Van Wert, Ohio

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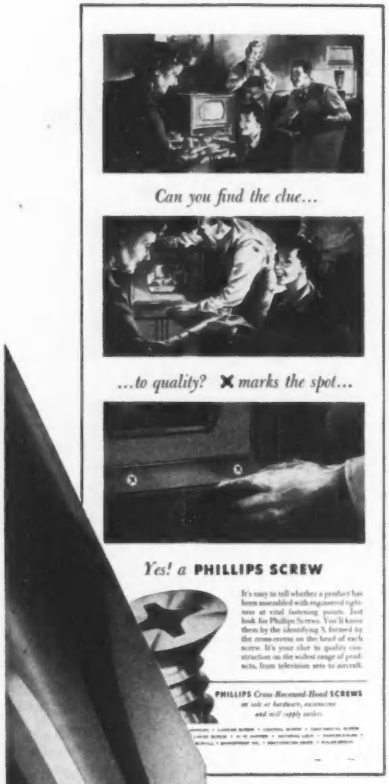

Part of the series of advertisements on Phillips Screws appearing in The Saturday Evening Post.

Can this clue to quality be found

on your product?

PHILLIPS SCREWS, with their identifying X formed by the cross recess, are recognized on sight as a mark of quality in well built products. The general public knows that Phillips Cross-Recessed-Head Screws make products stronger, better looking. 14 million readers of *The Saturday Evening Post* are being told that when it comes to assurance of quality, *X marks the spot.*

These screws cut driving time up to 50%, set up tighter, resist vibration. They are distinctively designed to give maximum strength of head, maximum driver strength. They eliminate driver skids and split screw heads. Whether you use Phillips wood screws, machine screws or tapping screws, you build a better product and you save time, work, money.

PHILLIPS *Cross-Recessed-Head* SCREWS

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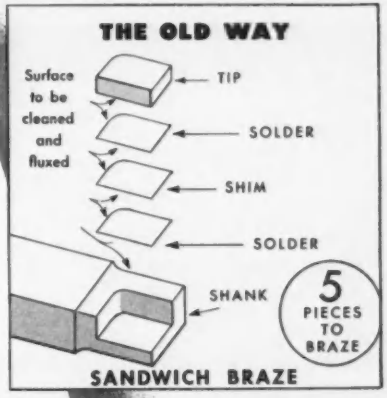
THE FASTENERS OF TODAY . . . AND OF THE FUTURE

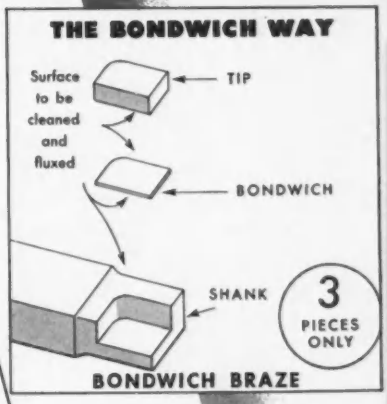
Problem:

How to Speed Up Sandwich Brazing Carbide Tool Tips



General Plate:

Provided the Solution with "BONDWICH"... a Composite Metal Combination



Carbide tipped tools give best results if the tip is brazed to the shank by sandwich brazing. However, the disadvantage of this method is the work involved in cleaning, fluxing, and positioning the three separate pieces of brazing alloy and shim material in addition to the tip and shank.

General Plate engineers solved the problem by bonding *into a single sheet* the three mentioned pieces. The result . . . a *General Plate composite metal* called "BONDWICH."

The two outer layers of "BONDWICH" are brazing alloy . . . the center piece a ductile shim. The bond is so perfect that when the brazing temperature is reached, complete wetting takes place. There are minimum voids in the final braze as the evenly wetted shim carries the braze all over. In addition to providing a better braze, "BONDWICH" speeds up carbide tip tool brazing, cuts production costs.

No matter what your metal problem, it will pay you to consult with General Plate. Their vast experience in cladding precious to base metals or base to base metals can overcome your problems . . . often reduce costs.

General Plate Products include . . . Precious metals clad to base metals, Base metals clad to base metals, Alcuplate (copper and aluminum), Silver Solders, Composite contacts, buttons and rivets, Platinum fabrication and refining, Age-hardenable #720 Manganese Alloy. Write for information.

Have You a Composite Metal Problem?
General Plate can solve it for you

GENERAL PLATE

Division of Metals & Controls Corporation

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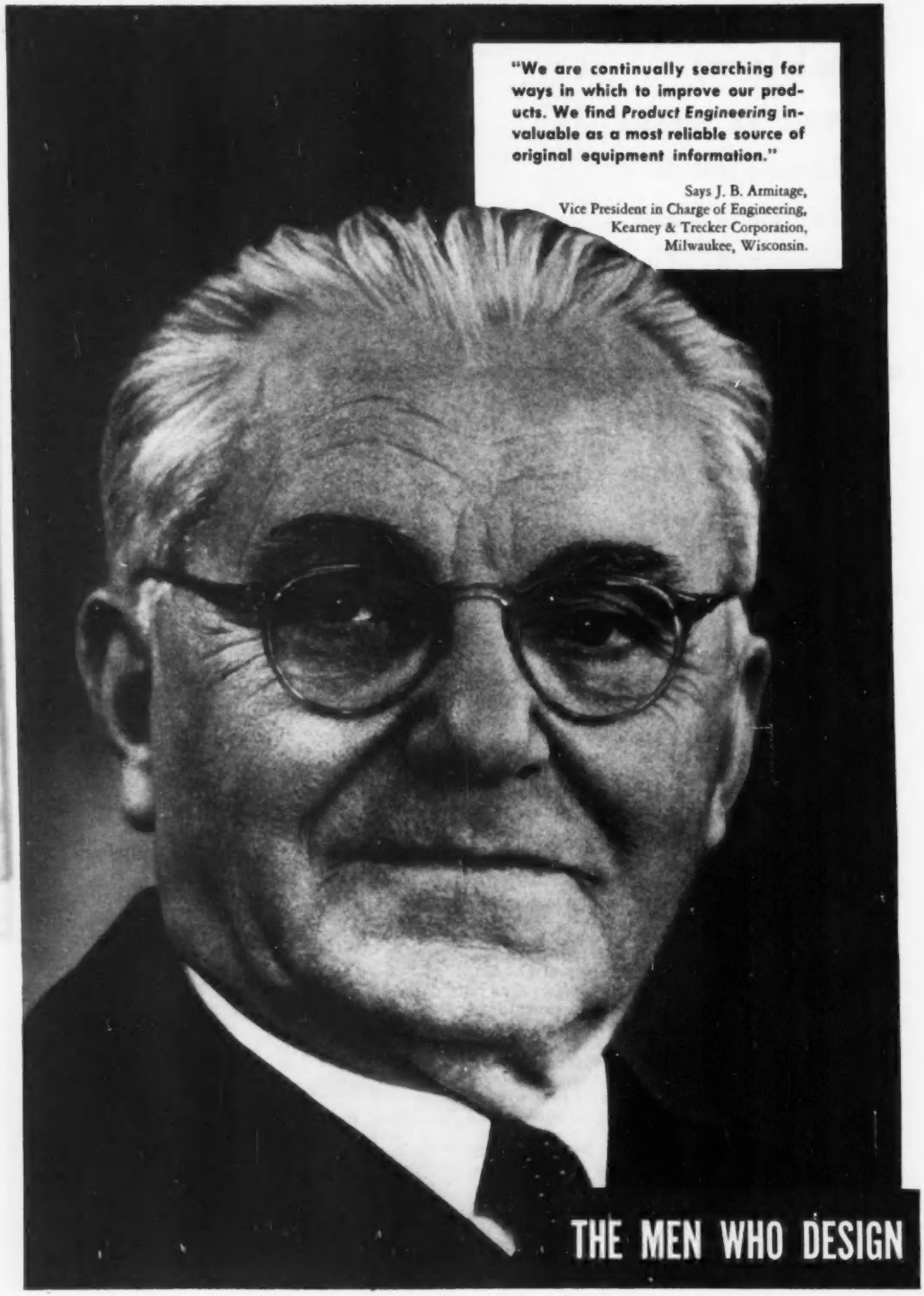
"We are continually searching for ways in which to improve our products. We find *Product Engineering* invaluable as a most reliable source of original equipment information."
Says J. B. Armitage,
Vice President in Charge of Engineering,
Kearney & Trecker Corporation,
Milwaukee, Wisconsin.
THE MEN WHO DESIGN

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Examine PRODUCT ENGINEERING's circulation—see for yourself how it penetrates deeper and higher into every market that buys and uses original equipment... 91 per cent of total circulation goes into the important hands of executives whose major function is to specify, approve and purchase parts, materials, components and finishes!

And most important of all, this circulation is *bought and paid for* by the corporations and personalities that make up the Original Equipment Market. *Bought and paid for* because these men want to read the kind of information PRODUCT ENGINEERING provides—edited exclusively for them by the *highest-paid* and *most-qualified* editorial staff of its kind—anywhere.

PRODUCT ENGINEERING's representative will be glad to show you complete details of PRODUCT ENGINEERING's circulation and readership in the machine tool, or any other segment of the Original Equipment Market. Next time he calls—just ask him!

PRODUCT ENGINEERING

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MORE ADVERTISING OF ORIGINAL EQUIPMENT* IS CARRIED BY PRODUCT ENGINEERING THAN BY ANY OTHER MAGAZINE IN THE WORLD!

*Every company which manufactures machines, equipment or appliances is a part of your giant Original Equipment Market. To reach and sell this big, repeat-order market, almost 600 display advertisers now invest, in PRODUCT ENGINEERING's proved readership, far more advertising dollars than are invested in the readers of *any other design magazine.* These advertisers *know* that from the men who read PRODUCT ENGINEERING flows the authority to specify, approve, and buy their products... in big quantities and in repetitive orders which boost sales and drop costs down.

AMERICA'S NEW PRODUCTS READ PRODUCT ENGINEERING

MicroRold® 430 polished sheets now available

During the current critical nickel shortage, the same close tolerance and uniformity of gauge that have made MicroRold 18-8 so outstanding are now being incorporated in MicroRold 430.

It is important that the individual end use be discussed with your distributor or with our metallurgical department.

MicroRold 430 has moderate ductility, good forming and bending characteristics, and can be drawn to a *moderate* degree. It can be brazed and soldered with the same facility as chrome-nickel grades and except where resistance to high stresses is a major factor, it welds satisfactorily by the usual methods.

MicroRold 430 is used extensively for interior architectural trim, bar, restaurant and soda fountain components, table tops, etc. Washington Steel Corp. is currently producing polished sheets in standard sizes, 20 gauge and lighter, to replace chrome-nickel material vitally needed for the national defense program.

WASHINGTON STEEL CORPORATION

Washington, Pennsylvania

Materials ~ AVAILABILITY AND TRENDS

CMP EFFECTS DEBATABLE

When the Controlled Materials Plan (CMP) goes into effect July 1, obtaining materials may become easier--but how much easier is questionable. There is skepticism about the CMP as it is now set up. Unlike the CMP of 1943, the current plan does not call for scheduling all of the steel, copper and aluminum. It will schedule only that part of these materials which is required to produce the articles on the "A" and "B" lists. The "A" list is easy--it consists of direct military items. The "B" list is the tough one: Highest on this list will be the essential industries such as transportation, mining, electric power, communications, agriculture and food processing. Lower on the list will be consumer "hard" goods such as autos and home appliances. For materials other than steel, copper and aluminum, and for products not on the lists, it will be everyone for himself, within the "rules" established by NPA, consisting of M orders, L orders, directives, ores allocations, special programs and other control devices.

STEEL OBJECTS

The Steel Products Advisory Committee, an industry group, has gone on record as opposing both CMP and cutbacks in specific uses of steel. It says that no cutbacks should be made without prior consultation with the committee as to uses of steel that would be freed under such orders. The committee feels that existing procedures, DO orders and allocation programs will provide adequate steel for defense and essential civilian needs.

TREND REVERSED: STEEL SHORT

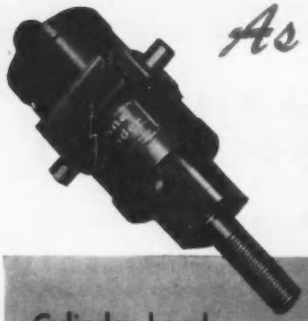
In January, this department reported: "Compared to other metals the iron and steel situation looks almost bright". This statement is no longer true. Plans to cut copper and aluminum usage by durable goods manufacturers and assemblers directly have been dropped by the National Production Authority except for parts they fabricate themselves. But end-use restriction of steel consumption in durable goods is retained in an NPA order. A further steel cutback of 10 percent is ordered for durable products in the third quarter of this year.

Thus, steel is still the important-and critical-material. Here is one method of saving steel tried by the manufacturer of a home freezer. In designing a new door, he uses a porcelain enamel coating on a lighter gage sheet steel. The finish is acid resistant, acceptable to the consumer, and saves more steel than would be possible with other coatings or stainless.

SUBSTITUTES IN APPLIANCES

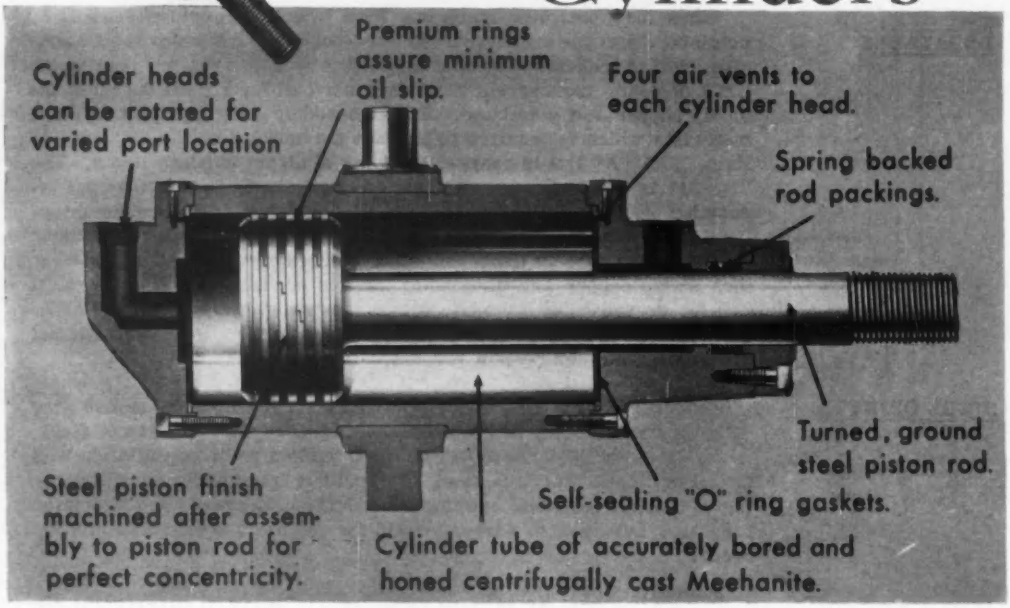
The limit on steel, plus the government's warning that tougher limitations on use of all metals are coming, are forcing appliance makers to take quick action. First noticeable change will be the disappearance of some models of heavy appliances, especially the fancier, "de luxe" types. Makers of radio and television sets, refrigerators, ranges, washers and other large items will drop their luxury models to save metal for standard lines.

But for a more "permanent" solution, standardization and substitution are the appliance makers' answer. For example, Philco has developed a "conservation model" television receiver. It uses no aluminum, and



As always DESIGNED AND BUILT FOR *FINEST* PERFORMANCE

Hanna H P HYDRAULIC Cylinders


Cylinder heads can be rotated for varied port location
Premium rings assure minimum oil slip.
Four air vents to each cylinder head.
Spring backed rod packings.
Turned, ground steel piston rod.
Steel piston finish machined after assembly to piston rod for perfect concentricity.
Self-sealing "O" ring gaskets.
Cylinder tube of accurately bored and honed centrifugally cast Meehanite.

for 50 years the Hanna nameplate has signified the finest engineered products. Meeting JIC Hydraulic Standards is nothing new for Hanna High Pressure Hydraulic Cylinders. They have always been designed, engineered and built to assure top-quality and dependable performance.

There is a complete line of standard Hanna H P Cylinders — for working pressures up to 1500 p.s.i. — to suit nearly every mounting requirement — to supply safe, smooth, economical power in thousands of industrial applications.

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For complete information and specifications on Hanna H P Hydraulic Cylinders, ask for new Catalog 233-A

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1765 Elston Avenue, Chicago 22, Illinois

takes even less copper, steel, and other scarce metals than is permitted by the various government cutback orders. Similar "conservation models" will soon come from the makers of refrigerators and other heavy appliances.

LONG RANGE

For the long range, the prospects are not too bright for the appliance industry. Further reductions in the use of metals will make it tougher for producers to maintain present output levels. The new 10 percent steel cut--70 percent of last year's consumption--for appliance production starts July 1. The fourth quarter (October-December) slash is certain to be even stiffer.

These reductions alone will mean fewer appliances. There is no way of estimating 1952 production now, but it's a safe bet it will be below 1951 and substantially under last year. Some appliances may disappear entirely because of shortages of other materials. Metals like tungsten, for example, aren't replaceable in many products.

MILITARY CONSERVATION

There is no reason why the armed services cannot get into the conservation act. A "critical analysis" of equipment and material being procured by the armed forces is under way by the Munitions Board, in the search for substitute materials. Examples of the types of possible substitutes the armed forces could make are: Suitable plastics for metals; synthetic for natural rubber; pressed, powdered or extruded parts to replace forged parts; printed electronic circuits instead of wired circuits; paints or other protective coatings instead of metal plating, and stamped parts instead of machined parts. Army Ordnance has already acted: The M-52 trench mortar fuze, for example, was formerly machined of aluminum rod. It is now transfer molded of cotton flock-filled phenolic plastics.

CHROME PLATE SUBSTITUTES

Current restrictions on decorative chrome plating will hit the auto industry hardest. But two finish manufacturers have come up with what look like practical substitutes: One is an inorganic, chromate-type "chrome-like" finish which can be applied to zinc--zinc coated on steel or zinc-base die castings. If this coating is covered with a synthetic lacquer, corrosion resistance greater than 100 hr of salt spray is reported. The other manufacturer claims a "chrome-like" effect with a synthetic enamel applied on zinc or directly on steel. Both methods should save copper and nickel, as well as chromium.

NONFERROUS OUTLOOK

The outlook for major expansion in future supplies of nonferrous metals is not encouraging, except for aluminum and magnesium. For copper, lead, and zinc we're dependent on new major ore discoveries, either domestic or foreign. For the light metals it's a case of developing additional supplies of cheap power, with mine output no serious problem.

A 1950 canvas of companies represented in the Mining & Metallurgical Society of America indicated a decline in domestic exploration and development for strategic metals of 96 percent; and an average for all nonferrous metals of 74 percent. These are percentage declines--1950 compared with 1940.

For the immediate future, domestic price controls and tariffs will raise hob with our imports. Plans recently announced for setting up an international program for stimulating production and allocating supplies will take plenty of time to effectuate--it's an exceedingly complex matter. Eventually, this may do some good. But it's wishful thinking to believe that the extraordinary demands for metals--for guns, plus "butter", plus hoarding, plus panic buying, plus speculation, plus government stockpiling-could ever be met. Something has "got to give".

TINNERMAN

Speed Nut Savings Stories

York Airs 70% Savings!

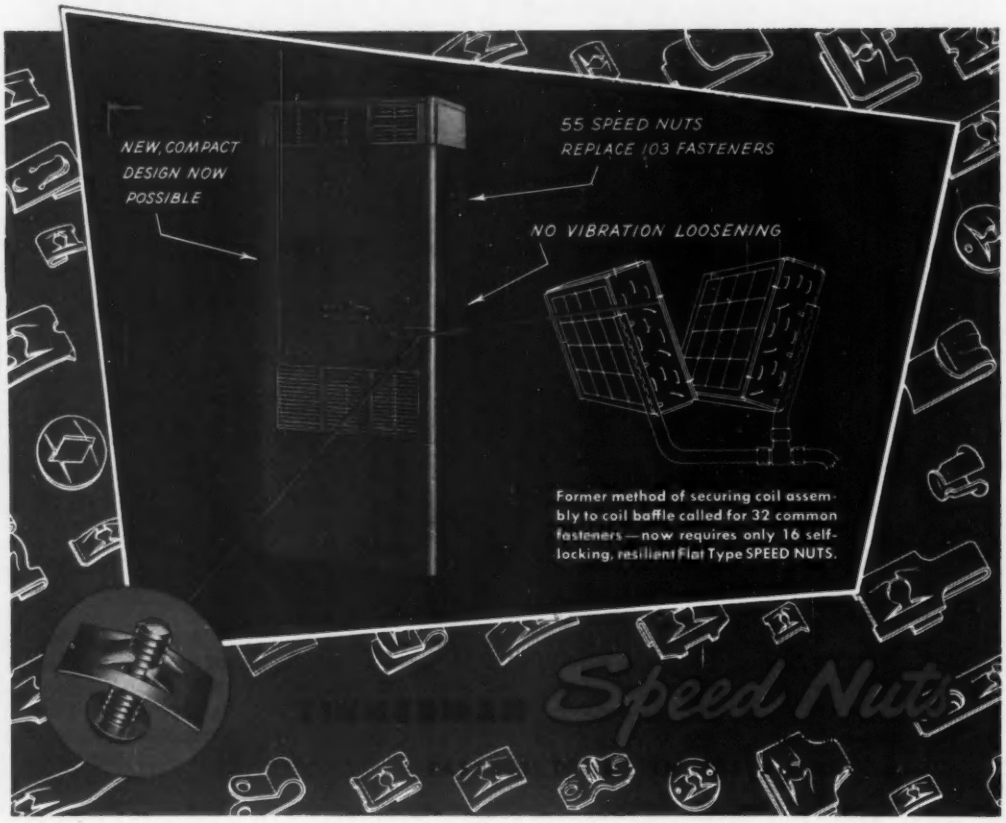
York Corporation replaces 103 fasteners with only 55 SPEED NUTS...cuts parts handling in half...makes 70% material savings.

Specifications for the latest Yorkaire Conditioner originally called for more than a hundred threaded nuts, lock washers, and other fasteners.

The Cost Saving Committee of the York engineering department, however, suggested that this unit be reviewed for possible SPEED NUT savings. A thorough fastening analysis was prepared in conjunction with Tinnerman sales engineers. Out of this report came evidence that "SPEED NUT brand fasteners could replace many of the fasteners specified . . . *and provide immediate savings of 70% in fastener costs.*"

Further savings—in assembly time, materials handling, and parts inventory—are expected when the Yorkaire hits full-scale production schedules.

Finding ways to save fastening dollars is a vitally important economy with today's narrowing profit margins. Ask for details on our comprehensive Fastening Analysis—and write for copy of new "Savings Stories." TINNERMAN PRODUCTS, INC., Box 6688, Dept. 12, Cleveland 1, Ohio. In Canada: Dominion Fasteners Ltd., Hamilton. In Great Britain: Simmonds Aerocessories, Ltd., Treforest, Wales.


NEW, COMPACT DESIGN NOW POSSIBLE
55 SPEED NUTS REPLACE 103 FASTENERS
NO VIBRATION LOOSENING
Former method of securing coil assembly to coil baffle called for 32 common fasteners — now requires only 16 self-locking, resilient Flat Type SPEED NUTS.
Speed Nuts

Judge Them By What They Do

Regrettably, there is an all too common tendency to belittle engineers in civil service. Both the men and the jobs they fill are too often looked down upon. The reasons are easy to understand. They all stem from the human failings of prejudice, envy and lack of understanding.

Ironically, the very people who belittle jobs in public service because of the low pay are loudest in squawking about the generous vacations, sick leaves and pensions that are generally granted in civil service. Such a contradictory attitude does not make sense and bespeaks envy and unfairness.

As to the low pay, it is common among men of high ideals and intellect to put salary secondary, and even last, when weighing the desirability of a given position. To such men the opportunities that the job offers to serve fellow men, to alleviate suffering, to unravel the mysteries of nature or to increase the fund of knowledge are among the first considerations. Were it not so, we would still be back in the dark ages. Innumerable men have given up lucrative jobs in order to serve humanity better, even though at relatively low pay. Money makes the mare go, but all men are not mares and the best ones are self starters.

As to the caliber of the engineers in public service, a listing of them would contain many names of men who are in the highest brackets of the profession. Many of them had made a great reputation for themselves before they went into civil service. Others built their reputation while in public service. The fluid magnetic clutch was developed at the Bureau of Standards by Bureau of Standards personnel. Another illustrious member of that organization is one of the inventors and developers of the mass spectrometer, which work he did in private industry prior to joining the Bureau of Standards. Many more instances could be cited.

One can get a better appreciation of the unusually high quality of these men when one contemplates the noteworthy accomplishments and great contributions of the Public Health Service, The Department of Agriculture, The Bureau of Mines, and the Bureau of Explosives of the I.C.C., all of which services have added greatly to the health and material welfare of the country. Many of the readers of PRODUCT ENGINEERING are quite familiar with the splendid work done by the civilian engineers in the Bureau of Aeronautics, Army Air Corps, Ordnance Department and many of the other departments of the services. Men of mediocre quality or abilities could not have made such records.

Cost or compensation are not yardsticks of value. Only by his accomplishments can we judge the real worth of a man. By that criterion the engineers in civil service are to be respected and lauded for the work they are doing.

G. F. Rodenholt

Reflections OF AN *Engineer*

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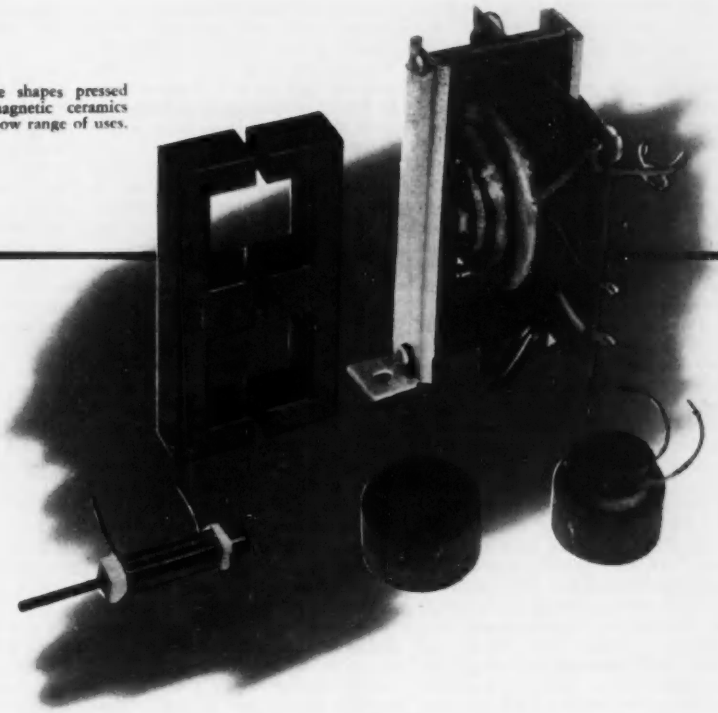


Fig. 1—Core shapes pressed from ferromagnetic ceramics or ferrites show range of uses.

Ferromagnetic Ceramics . . .

1. Have high permeabilities.
2. Need no laminating because eddy current losses are negligible.
3. Can be pressed-formed or extruded.
4. Perform satisfactorily at frequencies as low as 400 cps.

HAROLD A. GOLDSMITH
Project Engineer, General Ceramics and Steatite Corp., Keasbey, New Jersey

FERROMAGNETIC CERAMIC MATERIALS are a mixture of crystals of iron oxide with various other metallic oxides (not metals). Their general chemical formula is $MOFe_2O_3$, where M stands for a bivalent metal such as magnesium, nickel or zinc. No metals in metallic form and no organic compounds are contained in the ferrite material. The ferrite is a uniform, solid body similar in texture and mechanical properties to other oxides or silicate bodies.

These materials possess a combination of properties that put them in a class all by themselves; this is somewhere between the metallic alloys of iron and those of resin-bound iron dust. One of the outstanding features of ferrites is their high volume resistivity. This high volume of resistance, coupled with high permeabilities, constitutes one of the main advantages of this material over either iron dust or all-metallic core materials. The high volume resistivity keeps eddy-current losses to negligible values and permits the use of solid cores with alternating magnetic fields.

To reduce eddy currents when using conventional materials with alternating currents it is necessary to go to laminated core constructions. As the frequency increases above the lower audio frequencies, the allowable lamination thickness becomes progressively smaller with consequent difficulty in stacking and increase in cost. At yet higher frequencies it is necessary to use fine iron particles bonded by an or-

ganic resin, referred to as powdered iron. One of the limitations of this class of material is low permeability. Although the individual iron particles have very high permeabilities, a closed core of powdered iron exhibits a maximum effective permeability of only about 130. Compare this with permeabilities in the order of 10,000 for iron in the solid metal form. The low permeability exhibited by powdered iron is caused by the existence of air gaps between the individual particles. This same limitation is true of the powdered iron alloys and iron-molybdenum mixtures.

Ferrites, because of their natural high volume resistance, need not be powdered for use at high frequencies but may be used as a solid core. A comparison of properties of a silicon-iron alloy and powdered irons with ferrite shows the factors that must be kept in mind when selecting a material for a particular application. Table I lists some typical properties for the three classes of materials. It is apparent from this table that ferrites have much greater permeabilities than powdered irons. This relates to the true permeability of the material, as measured on closed magnetic circuits, i.e., toroidal cores. Silicon iron has initial permeabilities comparable to those of ferrite. On the other hand, refined nickel-iron alloys may have initial permeabilities many times as high. Maximum permeability of all irons are at present higher than those obtainable with ferrites. It would seem therefore that if high inductances are required, iron must be used. This thought is correct for the lower frequencies, say up to 1,000 cycles. But even at 1,000 cps it is necessary to go to very thin lamination thicknesses to keep eddy current losses from becoming excessive.

Aside from eddy current losses there is eddy current shielding to contend with. The eddy currents themselves set up lines of flux which contribute to the saturation of the core, thus reducing its permeability to the flux lines induced by the coil current. Because of this shielding or saturating effect, it is difficult to realize the true permeability of the laminated iron core as supersonic frequencies are approached. A ferrite core on the other hand exhibits its permeability up into the megacycle range. There is then a particular frequency where the realizeable permeability of the iron core is no higher than that of a ferrite core. For applications above this particular frequency, the selection of a ferrite for the core material may be of definite advantage. In the lower frequency ranges, the choice of core material must be made on the basis of an engineering compromise. In general, where power handling capacity is not of prime importance it is of advantage to use ferrite cores at frequencies above a few thousand cycles.

When power handling capacity is required it is still necessary to weigh the various factors involved before choosing between the ferrites and silicon iron. The saturation induction of ferrites at present are of the order of 3,000 to 4,000 gauss. Most metals have saturation inductions between 16,000 and 20,000 gauss. These figures give an indication of the power handling capacity of a magnetic structure, which is proportional to the square of the maximum operating flux density, to the frequency and to the volume of magnetic material. For applications at the power line frequencies, when space and power handling capacity are of prime importance, ferrites present no advantage up to now. However, when the application involves frequencies of 800 cps or higher, it may be advantageous to use ferrites even in medium power transformers. As frequencies in the kilocycle range are approached the superiority of the ferrites over silicon iron becomes substantially greater. Table I compares the core loss of a powdered iron (electrolytic iron), an 8 mil laminated silicon steel lamination and a ferrite core working at 15,000 cycles per second. The ferrite loss is about ¼ that of either of the other materials at 100 gauss operating flux density, and about 1/3 at 1000-gauss.

It is evident that ferrites now fill the gap that had existed between laminated steel for power applications at the low frequencies, and the powdered iron materials for low power application at the higher frequencies. Ferrites can be used to great advantage in medium and low power applications from about 1,000 cps up to 20 megacycles per second. In the future this upper

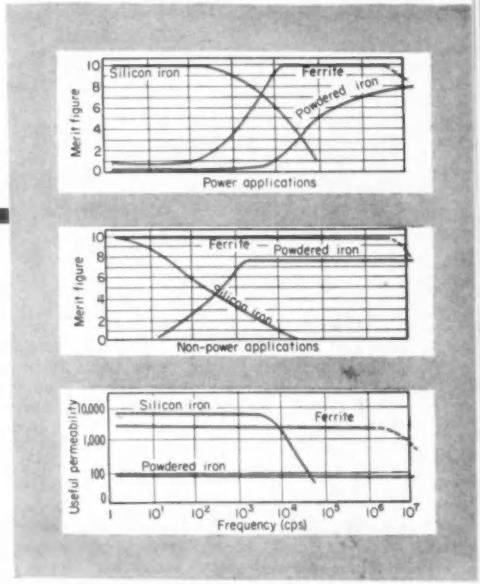


Fig. 2—Relative performance of silicon iron, ferrite and powdered iron as a function of operating frequency when power is to be handled (top) and when power is not involved (center). The "merit figures" are qualitative point ratings that are assigned each material to show how it compares with the other materials for applications at various frequencies. The merit figures are based on material cost, cost and ease of manufacture, weight, size, power losses and permeability. Bottom graph shows useful permeability of the materials as a function of frequency. Excellent performance of ferrite is shown.

Table I

	Powdered Iron	Ferrite	Silicon Iron
Initial Permeability	60–125	**400–1200**	400–600
Maximum Permeability	130	500–**4300**	**7000–10,000**
Saturation Flux Density (gauss)	.....	3000–4080	**20,000**
Coercive Force (oersted)	.....	**0.18**–1.0	0.2–0.6
Losses, Watts/cu cm at 15 KC/sec			
100 gauss	0.0024	0.**00062**	0.0040
1000 gauss	0.40	0.**12**	0.43
Resistivity, ohm-cm	.....	10^{+8}–10^{+9}	50 x 10^{-6}
Curie Point, deg C	.....	160–300	**700**
Density	7.4	**4.7 to 5.0**	7.6

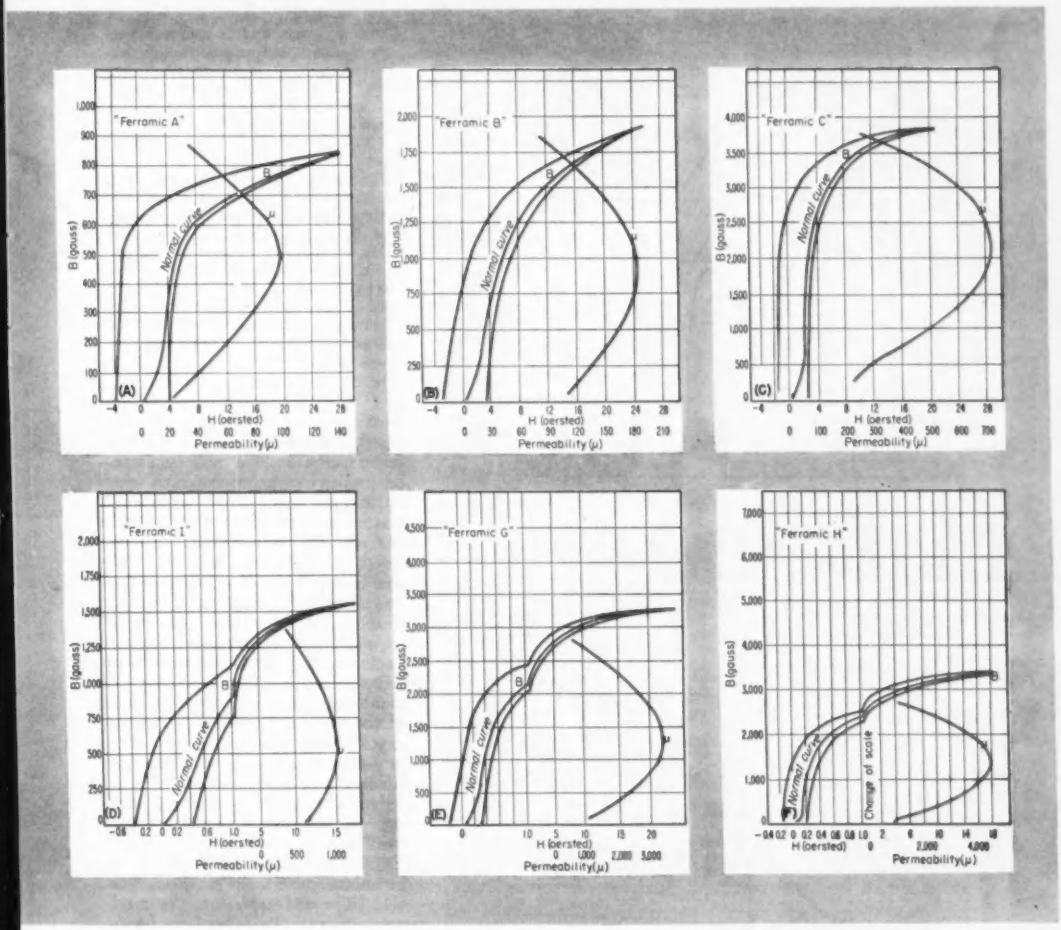


Fig. 3—Normal curve, hysterisis loop and permeability of typical ferrites as a function of operating flux density. Note the coercive force required for the various materials range from 0.2 to 4 oersteads. As would be expected the lower coercive force materials exhibit higher maximum permeabilities. Also illustrated by these curves is a rule of thumb. i.e. the coercive force is approximately that value of H corresponding to the value of B at which maximum permeability occurs.

Table II—Magnetic and Physical Characteristics of Typical Ferrites

"Ferramic" Type	Initial Permeability (μ_o)	Maximum Permeability ($\mu_{max.}$)	Coercive Force (H_c) oersted	Saturation Induction (B_s) gauss	Residual Magnetism (B_r) gauss	Curie Point deg C	Temperature Coefficient of Initial Permeability Percent per deg C	Volume Resistivity at room temperature ohm-cm
A	15	97	3.7	840	615	280	0.65	1×10^3
B	95	183	3.0	1900	830	260	0.04 max.	2×10^3
C	220	710	2.1	3800	2700	330	0.4	2×10^4
D	410	1030	1.0	3100	1320	165	0.3	3×10^7
E	980	1710	0.65	3800	1950	160	0.25	4×10^8
G	410	3300	0.25	3200	1050	160	1.3	1.5×10^8
H	850	4300	0.18	3400	1470	150	0.66	1×10^4
I	600	1010	0.40	1540	660	70	0.3	2×10^6

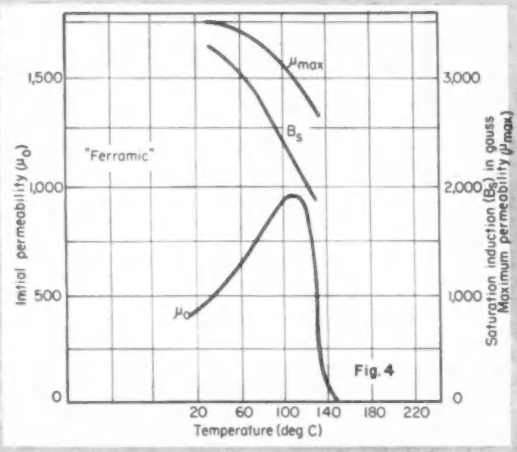


Fig. 4—Initial permeability increases with temperature while both maximum permeability and saturation flux density decrease. This incidentally causes one value of permeability between μ_o and μ_{max} to be independent of temperature, as explained in the text.

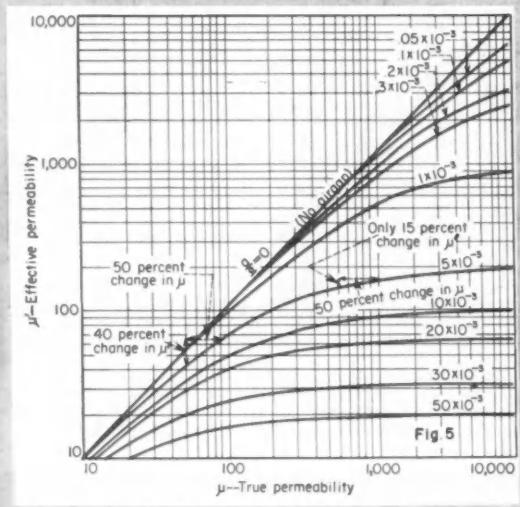


Fig. 5—Inclusion of an airgap in a magnetic circuit decreases its effective permeability. However, the presence of the airgap also decreases the effect that external factors, such as temperature, have on the operation of the magnetic circuit. This is evident from the above curves of effective versus true permeability for various ratios of airgap to length of the mean magnetic path (a/l).

limit probably will be extended to frequencies of 100 to 200 megacycles per second.

One application where both laminated steels and powdered iron were replaced by ferromagnetic ceramics with an improvement in efficiency and circuit performance is the core of a television horizontal sweep transformer. The sweep circuit operates at a frequency of approximately 15,000 cps, with higher frequency components present, and handles power of some 20 watts. The powdered iron core used formerly weighed 23 oz, while the ferrite core used now weighs only 5.6 ounces. Besides this saving in weight, the volume was reduced and the circuit Q (or magnetic efficiency) increased.

Of interest to the product engineer are the lower frequency (direct current to 0.5 megacycle per sec) characteristics of some commercially available ferrites. Perhaps the most fundamental property of a ferromagnetic material is the dependence of B, the induction or number of lines of magnetic flux per unit area, upon H, the intensity of the applied magnetic field. The relationship is expressed by the equation $B = \mu H$, where μ is the permeability of the material. A graphical plot of this non-linear function results in the familiar normal magnetization curve. The slope of a line connecting the origin with any point on the curve is by definition the permeability corresponding to the particular value of induction. The slope of this line at $B = H = O$ is the initial permeability, μ_o, corresponding to negligibly small values of operating induction. The slope of the line passing through the origin and tangent to the normal curve is the maximum possible slope and represents the maximum permeability. Another fundamental characteristic that may be obtained from the normal magnetization curve is the maximum induction B_s, of which the material is capable.

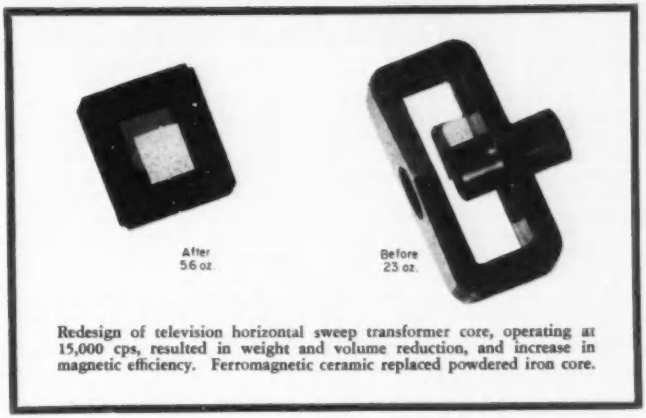
Since the properties of a ferromagnetic material depend on its previous history, the normal curve will follow only from the virgin or completely demagnetized state of the material. The "memory" or hysteresis effect of ferromagnetic materials is best depicted by the hysteresis loop. The latter is a plot of B versus H when the intensity of the magnetic field is varied in a symmetrical cycle of positive and negative values. The area enclosed by this loop is proportional to the hysteresis loss, which is a true power loss. The value of induction at $H = O$ is the residual flux density, B_r, while the value of H necessary to reduce the induction to zero is designated as H_c or coercive force.

Various ferrites may exhibit widely

different hysteresis loops. This fact is illustrated in Fig. 3, which includes as well the normal or virgin magnetization curves. Also plotted are the curves of permeability as a function of operating flux density. Specific values taken from these curves are presented in Table II for side by side comparison. Many combinations of properties are possible, such as high or low initial permeability with high or low maximum permeability. As would be expected, high maximum permeability goes along with low coercive force (less than 0.5 oersted). At present initial permeabilities of less than about 150 are regarded as low; between 150 and 600 as medium; and above 600 as high. Maximum permeabilities of less than 1,000 are low; 1,000 to 3,000 medium; and above 3,000 high. These figures are by no means intended to be absolute—and it may well be that in the not too distant future the range of maximum permeabilities may be extended to values exceeding 7,000. The saturation level of ferrites at present lies between approximately 1,000 to 4,000 gauss. Specimens with lower as well as somewhat higher values have been made in the laboratory.

As with all ferromagnetic materials the magnetization characteristics, i. e. saturation, coercive force, initial and maximum permeability, are functions of temperature. It is possible for one property, say maximum permeability, to be fairly stable while the other properties such as initial permeability may vary considerably. The curves of Fig. 4 illustrate this. Note that μ_o increases with temperature while μ_{max} decreases with temperature. Because of this behavior, there is a particular value of permeability that is independent of temperature. This value can be demonstrated by plotting a family of curves of permeability versus magnetizing field intensity for different temperatures. These curves will cross in a narrow region. Thus, if the material is operated at the intensity corresponding to that region, its permeability will be constant regardless of temperature.

For each ferromagnetic material there is a maximum temperature above which the material becomes paramagnetic or exhibits a permeability equal to unity. For various ferrites this temperature, the Curie point, may lie from below room temperature to about



Redesign of television horizontal sweep transformer core, operating at 15,000 cps, resulted in weight and volume reduction, and increase in magnetic efficiency. Ferromagnetic ceramic replaced powdered iron core.

400 C. The Curie points of various commercially available ferrites are listed in Table II, together with the temperature coefficient of initial permeability. This coefficient, expressed as percent change of permeability per deg C, is established by the linear part of the μ_o versus temperature curve below the Curie point. Sometimes the relatively large temperature coefficient of true permeability is cited as a drawback to the usefulness of ferrites in such critical applications as permeability tuning. Actually, in applications where magnetic circuits with airgaps are used, such as cup cores with airgap or tuning slugs, the temperature coefficient of effective permeability compares very favorably with those of the most stable magnetic materials commercially available.

The insertion of an airgap into a magnetic circuit has the effect of reducing the useable permeability of the material. Calling the permeability as measured on a closed magnetic circuit "true" permeability, then the permeability measured with an airgap is the "effective" permeability.

It has been proven that: $\mu' = \dfrac{\mu}{1 + \dfrac{\mu a}{l}}$

where: μ' = effective permeability
μ = true permeability
a = length of airgap
l = mean magnetic path

From this equation, which is plotted in Fig. 5, for various values of a/l it

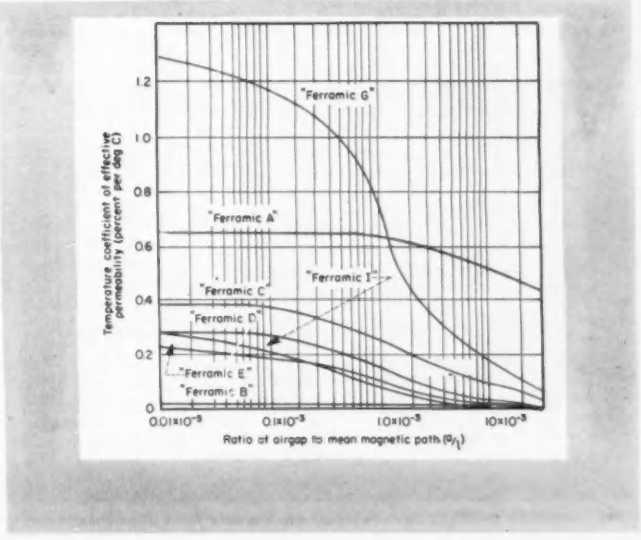


Fig. 6—These curves illustrate the stabilizing influence the presence of an airgap has on a magnetic circuit. The larger the gap in proportion to the overall length of the circuit, the less will temperatures change affect permeability. The effect of an airgap varies for different materials.

may be seen that the effective permeability approaches asymptotically a limit, the value of which is a function of airgap (meaning a/l) only.

Thus, if a magnetic circuit contains an airgap, the effect of a change in true permeability of the material, perhaps because of temperature changes, will not be as noticeable as in a circuit without airgap. Also, assuming for this discussion a 50 percent change in true permeability due to some external factor, in a magnetic circuit containing a fixed airgap, then the percent change in effective permeability will be less for a material with high true permeability, than for a material with low true permeability. For example, if in a magnetic circuit having a ratio of airgap to magnetic path of 5×10^{-4} a material having a μ_o of 1000 is used, then a change in this permeability by 50 percent changes the effective permeability of the circuit only by 15 percent. But if a material with a μ_o of 100 is used, then a 50 percent change causes a 40 percent change in the effective permeability.

On the basis of curves in Fig. 5 and on temperature coeffcient measurements on ring samples of ferrites having permeabilities as listed in Table II, the temperature coefficient of effective permeability of the various ferrites for different airgaps was calculated. The results are plotted in Fig. 6. With these curves, it is possible to predict the temperature coefficient of effective permeability for any particular combination of airgap and material. These coefficients are low when an airgap is incorporated in the material. As an illustration of this, consider a tuning slug (approximate dimensions: 0.60 cm in diameter, 2.5 cm long made of material "E" 174. This material has an initial permeability of 980 and a temperature coefficient of true permeability equal to 0.25 percent per deg Centigrade. The material exhibits an effective permeability (μ'_e) of 3.7 and a temperature coefficient of effective permeability of less than 0.001 percent per deg Centigrade.

The dependence of the normal magnetization curve on temperature is shown in Fig. 7 for several materials. As temperature increases, maximum permeability always occurs at lower operating flux densities. This is true whether maximum permeability remains constant with temperature changes, as for material *D*, or varies as it does for material *G*. Also, the coercive force of these materials decreases with increase in temperature.

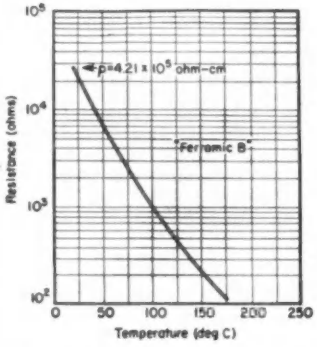


Fig. 8—Volume resistance of a magnetic ceramic varies inversely with temperature. Ferrites are classed as semi-conductors whose resistivity is a logarithmic function of temperature. Temperature sensing resistors could be designed to take advantage of this property of ferrites.

The behavior of the properties of ferrites with changing temperatures opens possibilities for some interesting applications. Since the material loses its ferromagnetism after passing the Curie point it is possible to build relays which open or close at a well defined temperature, viz. the Curie point of the material. As initial permeability changes rapidly after the Curie point, it may be possible to utilize this effect in telemetering information by frequency modulating an oscillator as a function of temperature over a narrow range of temperature. Ferrites are semi-conductors and as such their resistivity is a logarithmic function of temperature. A typical resistance vs. temperature curve is shown in Fig. 8. This effect may find application in the making of temperature sensitive resistors.

To sum up, ferrites now take a place somewhere between low frequency, high flux density steels and the low permeability, high frequency powdered iron materials. Ferrites are ideally suited to applications where power handling capacity with (low magnetic or electrical losses) is required above a few hundred cycles per second. Designers of high frequency electric motors (400 cps and up) are investigating the practicability of substituting molded ferrite parts for the laminated iron structures now used. For high frequencies, where permeabilities greater than those obtainable with powdered iron are wanted, ferrites are alone suited. Beyond this, the usefulness of magnetic ceramics extends into the high megacycle per sec range. In general, the magnetic circuit efficiencies obtainable with the ferrites compare favorably with other materials over the whole frequency spectrum.

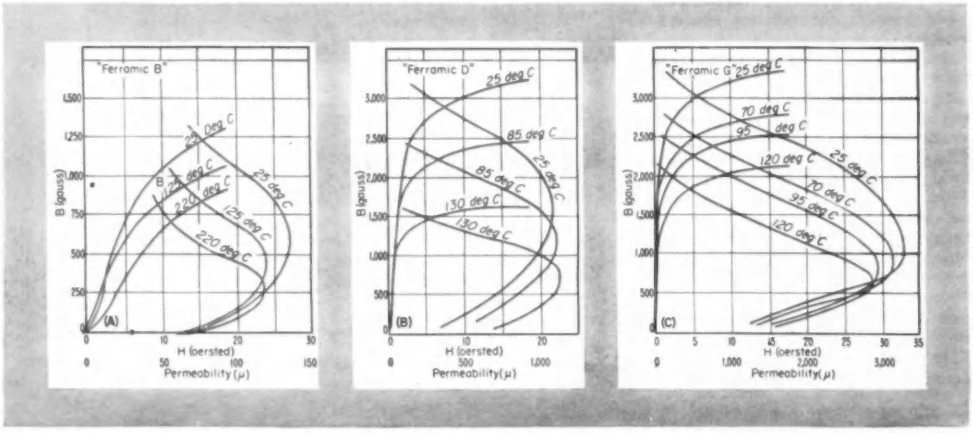


Fig. 7—Normal magnetization as a function of temperature for some typical ferrites.

Resistance Network Analogue For Solving Vibration Problems

WALTER W. SOROKA
Division of Engineering Design, University of California

ELECTRICAL CIRCUITS are frequently used as simulators for the experimental study of problems in dynamics, impact and vibration. For one example see "Mechanical and Electrical Analogues for Vibration Isolation Problems", PRODUCT ENGINEERING, February, 1950. When the problem is one of computing rather than experimenting such circuits are called analogue computers.

Analogues can be devised to multiply numbers electrically using a circuit that consists of potentiometers and a source of constant voltage. Analogues can be devised to add numbers electrically using a circuit that consists of sources of adjustable voltage and fixed resistors.

The basic potentiometric system for multiplying three numbers together is

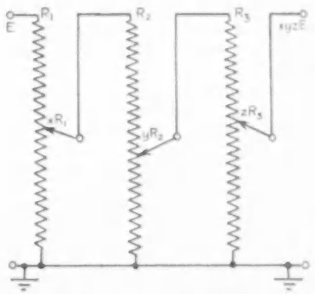


Fig. 1—Basic potentiometric network for obtaining the product of three factors.

shown in Fig. 1. The values R_1, R_2 and R_3 are the total resistances of the respective potentiometers. The source of constant voltage E is connected across the first potentiometer.

To find the product of three numbers n_1, n_2 and n_3 the middle tap of the first potentiometer is set at the fraction x, equal to n_1/R_1, of the total range R_1; then the resistance to ground or reference at the middle tap is xR_1, and the voltage across the middle tap and ground is then $(xR_1/R_1)E$ or xE. Also, this voltage is impressed across the second potentiometer. Next, the middle tap of the second potentiometer is set at the fraction y, equal to n_2/R_2, of the total range R_2; then the resistance to ground at this middle tap is yR_2, and the voltage to ground is $(yR_2/R_2)xE$ or xyE, and this voltage is impressed across the third potentiometer. In similar manner, with the middle tap of the third potentiometer set at the fraction z, equal to n_3/R_3, of the total range R_3, the final potential $xyzE$ will be indicated by a voltmeter at the end of the circuit.

Since

$$x = n_1/R_1 \qquad y = n_2/R_2 \qquad z = n_3/R_3$$
$$n_1n_2n_3(E) = (xyzE)(R_1R_2R_3)$$

in which the resistances R_1, R_2, and R_3 and the voltage E are known constants, hence the product $n_1n_2n_3$ can be readily determined from the fraction xyz of the voltage impressed across the first potentiometer.

This circuit, obviously, can be used to find values of n_1, n_2 and n_3 when they are adjustable variables or parameters, the product of which must equal a required value. The operation simply requires adjusting the middle taps of the potentiometers.

Some question might arise as to the certainty of the product xyz as influenced by the potentiometer loading. If the current drain through the middle tap of the potentiometer is an appreciable proportion of the entering current, then the voltage drop from tap to ground will not bear the same ratio to the total voltage as the geometric setting of that tap. In the analogue of Fig. 1, it is assumed that these ratios are the same.

To reduce the potentiometer loading to a negligibly small effect, relatively little current should be drawn off at the middle tap. This condition will be fulfilled by making the resistance R_2 large compared with R_1, and R_3 large compared with R_2. A factor of 100 would be excellent, and a factor of 10 should be adequate for most problems. If it is not desired to set R_1 and R_2 in accordance with dial markings, they may be set by balancing them in a Wheatstone bridge circuit against an unloaded standard potentiometer. With this method, all potentiometers may be of equal resistance, the loading effect being compensated for in the setting of the tap.

An adding circuit for summing five factors is shown in Fig. 2; it consists of a bank of five identical resistors each having a resistance value R_0. The voltages at the resistor terminals are indicated as p_1E, p_2E, p_3E, p_4E and p_5E, where p_1, p_2, p_3, p_4, and p_5 refer to different products, such as the xyz

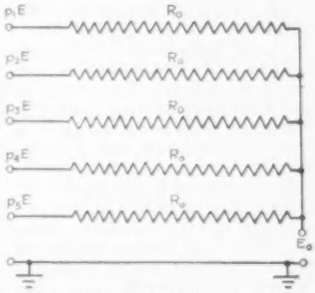


Fig. 2—Adding circuit for summing five factors, it consists of a bank of five identical resistors.

term of Fig. 1, obtained as output voltages from a group of potentiometer multiplying networks each similar to that of Fig. 1. These output voltages then serve as inputs to a bank of identical resistors R_0, the resistance value of which must be large as compared with the potentiometer group resistance. The output voltage E_0 of the network shown in Fig. 2 is

$$E_0 = (p_1 + p_2 + p_3 + p_4 + p_5)\,E/5$$

Multiplying networks and summing networks can be combined for the solutions of simultaneous equations, and thus used as tools in many design studies, such as the evaluating of dynamic absorbers for correcting vibrations difficulties in a given machine; or they can be used to study the effects of machine mass, position of the center of gravity, mount stiffness and damping, and mount location on the isolation of machine vibration. How

such a resistance network can be designed will be discussed by studying the damped dynamic absorber.

DYNAMIC ABSORBER. When a machine operates over a wide speed range, various degrees of roughness are experienced depending on how near to its critical speed the machine runs. The response curve for such a machine on its foundation will resemble the full line of Fig. 3. If running at or near the critical speed is the normal operating point for this machine (essentially a constant speed machine), operation at normal speed can be made smooth by attaching a small mass (1/10th to 1/20th of the machine mass) on a spring to the frame of the machine.

The absorber mass and the spring stiffness are so chosen that the absorber natural frequency is the same as that of the machine mass on its foundation. With absorber attached, assuming constant excitation, the response curve of the machine is then similar to the dotted line of Fig. 3. The machine vibration is thus considerably reduced at operating speed.

If the machine is required also to operate at other speeds the situation has not been improved by the introduction of the absorber. For this condition, there are two rough operating positions, one at a speed below the original critical speed and one at a speed above that critical.

To give relatively smooth operation over the entire speed range a compromise must be made—and here is where the problem of design enters primarily. An optimum amount of damping must be introduced across the absorber spring and the tuning must be changed slightly for optimum results. When the optimum damping and optimum tuning have been determined, either by calculation or by test, the final best compromise for the response curve will be similar to that shown in Fig. 3 by the dashed line.

An electrical circuit will be developed and designed to provide values of response that may be used to plot response curves of the third type. All parameters (masses, damping, springs, forces) are instantly adjustable by the turn of a dial so that various systems and wide variations within a given system may be studied rapidly and conveniently. The apparatus is not limited, to a two-degree-of-freedom system, but may be extended to more complex systems by the proportionate addition of more potentiometers.

THEORY OF THE METHOD. To show how the circuit is designed, first consider the differential equations of motion of the machine-absorber system with damping present in both. Where the subscript 1 applies to the machine, and subscript 2 to the absorber, and

m = mass, lb-sec²/in.
t = time, sec
x = displacement, in.
$\dot{x}$ = velocity (first derivative of x with respect to t), in./sec
$\ddot{x}$ = acceleration (second derivative of x with respect to t), in/sec²
ω = speed, angular velocity, radians per sec
F = force, lb
c = coefficient of damping
k = spring constant

the two differential equations that must be satisfied are

$$m_1\ddot{x}_1 + c_1\dot{x}_1 + c_2(\dot{x}_1 - \dot{x}_2) + k_1x_1 + k_2(x_1 - x_2) = F_1 \sin \omega t \quad (1)$$

$$m_2\ddot{x}_2 + c_2(\dot{x}_2 - \dot{x}_1) + k_2(x_2 - x_1) = 0 \quad (2)$$

The differential Eqs (1) and (2) have the solution

$$x_1 = a_1 \cos \omega t + b_1 \sin \omega t \quad (3)$$

$$x_2 = a_2 \cos \omega t + b_2 \sin \omega t \quad (4)$$

To evaluate a_1, b_1, a_2, and b_2, substitute Eqs (3) and (4) into Eqs (1) and (2) and solve simultaneously the resulting four algebraic equations for each value of the speed ω in the range being studied. The response A of the machine mass is then given by

$$A = \sqrt{a_1^2 + b_1^2}$$

The Eqs (1) and (2) become four algebraic equations after substitution of Eqs (3) and (4) because the resulting sums of sine components and of cosine components in each equation must equal zero independently.

$$-m_1\omega^2a_1 + k_1a_1 + k_2a_1 - k_2a_2 + \omega c_1b_1 + \omega c_2b_1 - \omega c_2b_2 = 0 \quad (5)$$

$$-\omega c_1a_1 - \omega c_2a_1 + \omega c_2a_2 - m_1\omega^2b_1 + k_1b_1 + k_2b_1 - k_2b_2 - F_1 = 0 \quad (6)$$

$$-k_2a_1 - m_2\omega^2a_2 + k_2a_2 - \omega c_2b_1 + \omega c_2b_2 = 0 \quad (7)$$

$$\omega c_2a_1 - \omega c_2a_2 - k_2b_1 - m_2\omega^2b_2 + k_2b_2 = 0 \quad (8)$$

For any particular value of the exciting frequency and for a given system, there are only four unknowns in this set of equations, namely, a_1, a_2, b_1, and b_2. Consequently, a simultaneous equation-solving device, either mechanical or electrical in nature, can be used for evaluating these unknowns. The primary interest insofar as machine response is concerned is in a_1 and b_1. But to design the absorber spring for adequate strength, to provide the necessary clearance for movement of the absorber mass, and to design the absorber dashpot, the magnitudes a_2 and b_2 are also required; the square root of the sum of their squares is the amplitude of the absorber mass.

SIMULTANEOUS EQUATION CIRCUIT. The combination of basic resistance circuits for multiplying and for adding shown in Fig. 4 is a typical network that can be used in the solution of simultaneous equations.

As shown and labeled in Fig. 4, the network represents Eq (5). This network contains seven sets of potentiometers, one set for each product in Eq (5). Each potentiometer is labeled with the parameter or variable it represents. Each set of potentiometers is equipped with a single-pole double-throw switch for sign control to make a product plus or minus depending upon its sign in the equation. A battery B supplies each potentiometer set with a constant input voltage $\pm E$. The galvanometer G indicates the sum of the outputs of the potentiometer sets.

By setting the given system values on the potentiometers and then adjusting the a_1, a_2, b_1 and b_2 potentiometers until the voltage sum for the system becomes zero, obviously, the settings of these potentiometers will be a solution of the equation.

To solve the group of simultaneous Eqs (5) through (8), similar networks must also be set up to represent Eqs (6), (7), and (8). On each of these networks, similar adjustments are made for each equation in turn until all four equation circuits read zero with the same settings on corresponding variable potentiometers. Since the values of a_1, a_2, b_1 and b_2 are unknown, their values are first estimated by trial, and then readjusted by an organized procedure until the equations are all finally satisfied simultaneously.

Potentiometers 3, 5 and 7 are identical potentiometers representing a_1, and may be ganged on a single shaft so that only one knob is needed on the front panel to represent the amplitude component a_1. Similarly, potentiometers 6 and 8, 12 and 15, and 13 and 16 could be paired.

Potentiometer 2 should be wound with a square taper winding, so that the resistance is proportional to the square of the displacement of the middle tap. If such a potentiometer is used, then it may be ganged together with 11, 14 and 17 and the potentiometer dial would merely indicate ω. This arrangement would make it unnecessary to calculate ω^2 and to set it with a separate knob. It is also possible to get ω^2 by cascading two ω potentiometers.

In Eq (1), $F_1 \sin \omega t$ is the force acting on the machine and is of constant amplitude at all frequencies. If the force varies with speed, as it would if it were the result of unbalance, no complication is introduced into the design of the network since then it is necessary only to operate the F_1 poten-

tiometer from the same shaft that operates the ω^2 potentiometer.

It is not necessary to set up all four equations with independent potentiometers. Most of the potentiometer sets of Fig. 4 could also be used with Eq (6) and then with Eq (7) and finally with Eq (8). To set up Eq (6), only two of the 3-gang a_1 potentiometers are required. The entire gang of ω-potentiometers are used. An additional b_1 potentiometer must be provided, so that a 3-gang unit is available. Also a single potentiometer is needed to represent F_1. The only other additions necessary is to provide another a_2 potentiometer for ganging with potentiometer 9 and another b_2 potentiometer for ganging with potentiometer 18 to solve Eqs (7) and (8).

A four-position switch with twenty-two banks would provide for instantaneous switching from equation to equation, and each equation circuit then could be examined in turn. The normal procedure for solving the equations would be to set the 22-bank switch on Eq (5) position, set the coefficient potentiometers to their appropriate values (based on unity as the maximum value in the equation), set the operating speed ω, then set the unknowns, a_1, a_2, b_1 and b_2 to estimated values and adjust the a_1 knob until the galvanometer reads zero.

Leaving all knobs set, the 22-bank switch is next turned to the Eq (6) position. This equation circuit is naturally out-of-balance so that a deflection of the galvanometer will occur. The galvanometer is brought back to zero by adjusting the a_2 *knob*.

On Eq (7) position, the galvanometer is nulled by adjusting the b_1 knob and on Eq (8) position by means of the b_2 knob. By this time the Eq (5) circuit is again out of balance, so the procedure is repeated all over again.

It is important that only the one knob of the unknowns be adjusted for each equation position. After a few iterations all the circuits will have come into balance, so that in moving the 22-bank switch from position to position, the galvanometer remains nulled. The true values of a_1, a_2, b_1 and b_2 may be read from the dials and the appropriate scale factors applied to convert these values to actual amplitudes of the machine and absorber mass.

In dealing with simultaneous algebraic equations, a word of caution is usually in order. Depending on the relative magnitudes of the various coefficients, simultaneous algebraic equations may converge rapidly to a solution, or the convergence may be difficult to obtain.

Convergence is usually most rapid if in each equation circuit the unknown chosen for adjustment has the largest net coefficient. When three potentiometers are ganged together to represent three terms of the equation containing the same unknown, the net coefficient for that unknown is the algebraic sum of the three coefficient of the unknown. Consequently, in using this network for solving dynamical problems, or other problems involving linear simultaneous equations, an optimum choice should be made as to the order in which the equations are to be balanced. If difficulty is experienced in getting balance by adjusting the variable potentiometers in a given order, a different order may result in an improvement in rate of convergence.

ACCURACY OF THE METHOD. The potential accuracy of the resistance network method is unlimited.

The method for obtaining greater precision is as follows. The first answers for a_1, a_2, b_1 and b_2 are substituted into the given equations and the sum of the terms on the left of each of the Eqs (5) to (8) is computed on a desk calculator to the precision desired. This sum will not be zero because the roots read from the unknown potentiometers are not exact. Call these residues ΔA, ΔB, ΔC and ΔD, respectively.

These residues may be reduced by solving the Eqs (5) to (8) over again with a_1, a_2, b_1 and b_2 replaced by Δa_1, Δa_2, Δb_1 and Δb_2 and the terms ΔA, ΔB, ΔC, and ΔD introduced into the corresponding equations on the left side. For this operation, three more potentiometers are required, a ΔA potentiometer for Eq (5), a ΔC potentiometer for Eq (7) and a ΔD potentiometer for Eq (8). Since Eq (6) already has a constant-term potentiometer for F_1, this potentiometer can now be used for ΔD. The values Δa_1, Δa_2, Δb_1 and Δb_2 that satisfy these equations are corrections to be added to the values a_1, a_2, b_1 and b_2 previously obtained.

If still greater precision is required, the corrected values may be substituted into the equations, new residues obtained by calculation, and these used in a new cycle of operations to obtain further corrections.

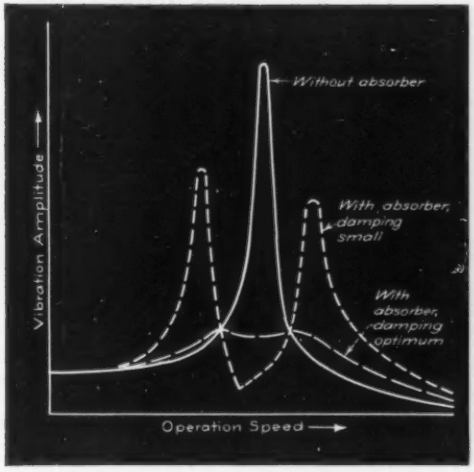


Fig. 3—Amplitude response curves of a machine with and without a dynamic absorber over a range of operating speeds.

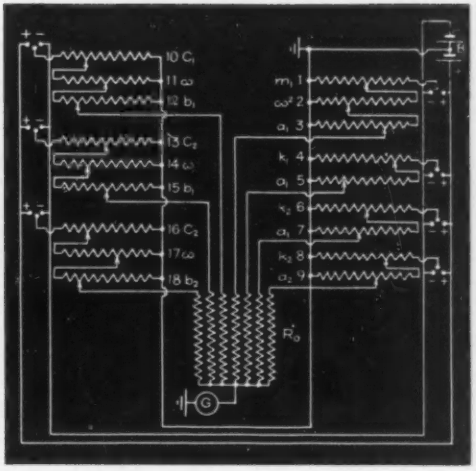
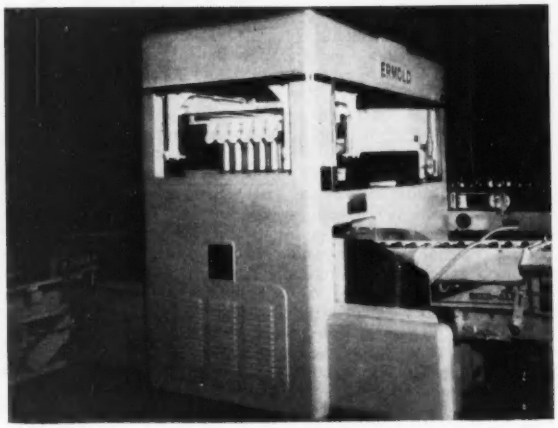


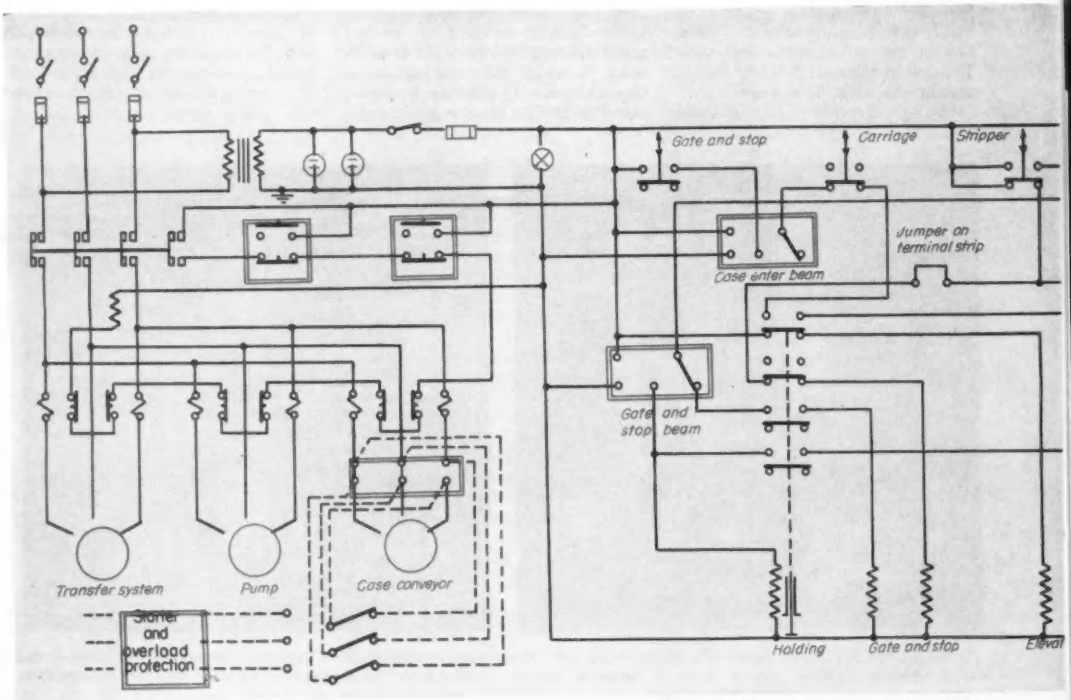
Fig. 4—Typical basic resistance circuits for multiplying and adding combined to solve one of a set of simultaneous equations.

Self-Contained Hydraulic System

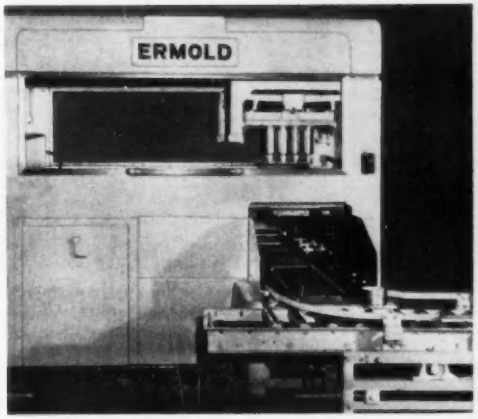
A combination of hydraulic actuators and electric-motor-driven conveyors was decided upon by the engineers of the Edward Ermold Co. of New York for their new Automatic Unpacker, designed to remove bottles or containers from cartons and cases. Mechanically actuated mechanisms to achieve all the functional characteristics which were called for by research and field surveys would have necessitated an impractically large machine or an inherently unstable mechanism and power requirement. A pneumatic machine would require expensive compressing and storage equipment or absolute dependance upon the compressed air supply available in the user's plant. The hydraulic system decided upon, built up of replaceable standard components, overcomes these objections and gives outstanding flexibility of case and container size and operating speed. The proper sequence of operations is determined by an electrical system shown in schematic.



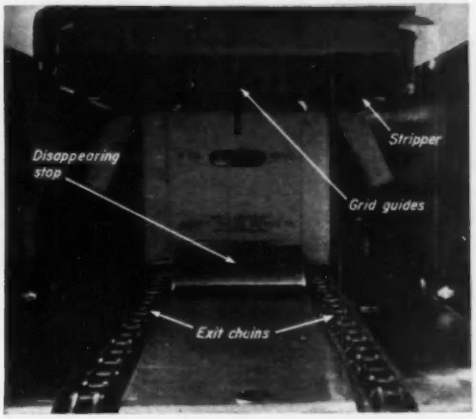
LOADED CARTONS enter machine from conveyor at the right, and are raised in turn to the Grippers, which pick bottles out and deposit them on top conveyor. Empty cartons are ejected at the left.



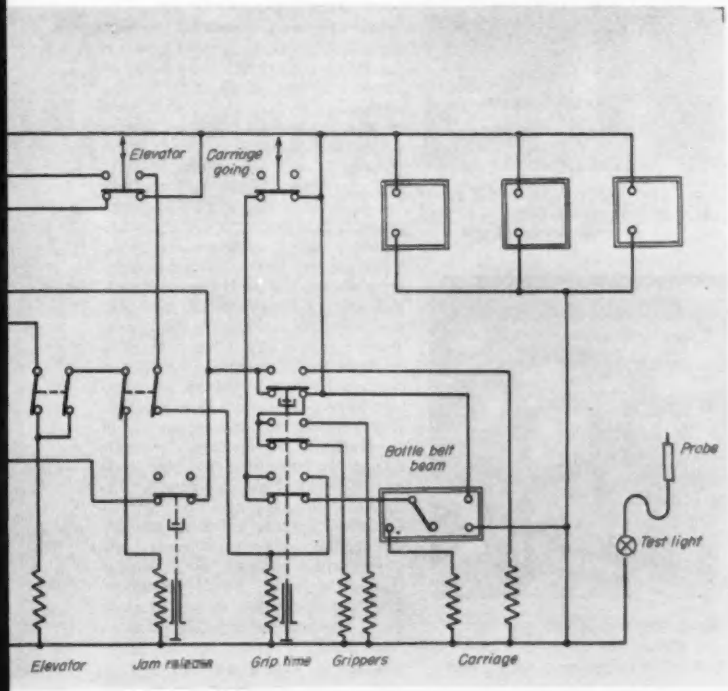
Simplifies Design of Case Unpacker



GRIPPER ASSEMBLY grabs the bottle necks and is moved to the left with each batch by a stationary hydraulic cylinder The carton leaves on the chain conveyor below.

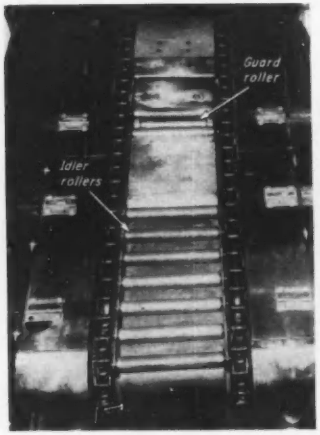


DISAPPEARING STOP holds the case in position to be elevated through the stripper grid guides which control the flaps and position the case as it is raised into the grid.

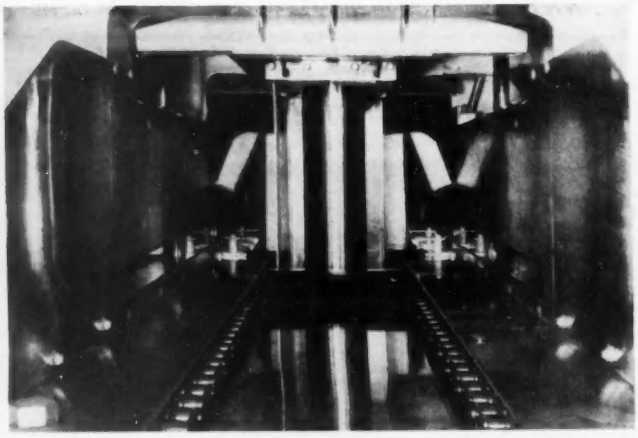


ELECTRICALLY CONTROLLED hydraulic system powers the major components of the unpacker. A loaded case passes the gate, breaking the entrance beam and a beam to lift the gate and stop. The rising stop trips a switch to lift the elevator after the case has been centered. The elevator lifts the case, operating a switch to close the gripper fingers about the bottles as the elevator reaches the top. The grip-time switch then times out, the holding solenoid is de-energized and the elevator starts down. A stripper switch is pushed down, the gripper carriage moves forward and the gate and stop start down. The carriage is lowered near the completion of the forward stroke, depositing the bottles on a continuously operating mesh conveyor. At this time the grippers release the bottles; the carriage continues forward and is again raised to permit the bottles to pass beneath the grip fingers. The carriage cannot return until the bottles have cleared a photoelectric beam across the mesh conveyor. In the meantime, the elevator has been lowered. At the bottom of the elevator stroke, the stripper actuates a switch to lower the gate and stop to permit another case to be fed into the unpacker and the cycle is then repeated.

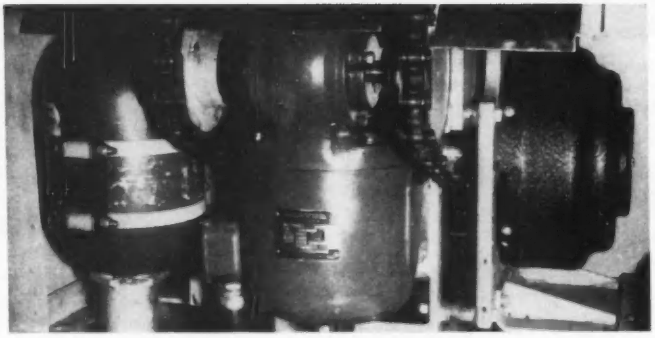
(*continued on next page*)



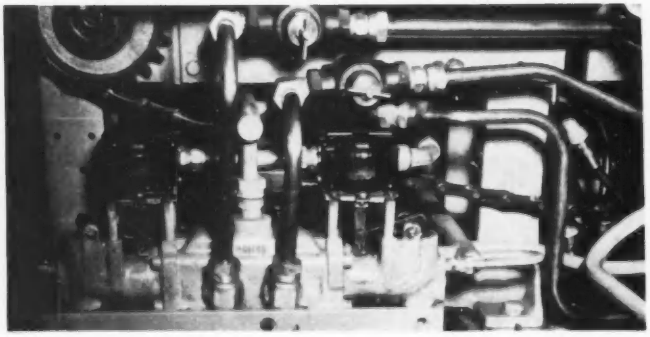
GUARD ROLLER rises to hold the entering case until the unloading cycle on the previous case is completed.



HYDRAULIC ELEVATOR raises the case after it is carried up to the disappearing stop. The next case is held on entrance idlers by the guard roller until the elevator is lowered and the disappearing stop drops to clear the passage.



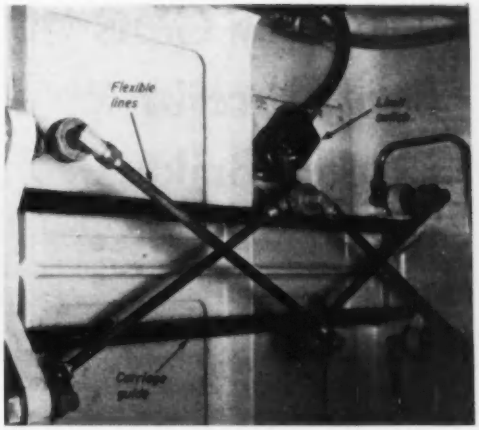
GEAR HEAD MOTOR drives the roller chain case conveyor, while the Fairbanks Morse axial air gap motor, fitting neatly into the machine outlines, drives the main Racine hydraulic pump located behind the accumulator on the left.



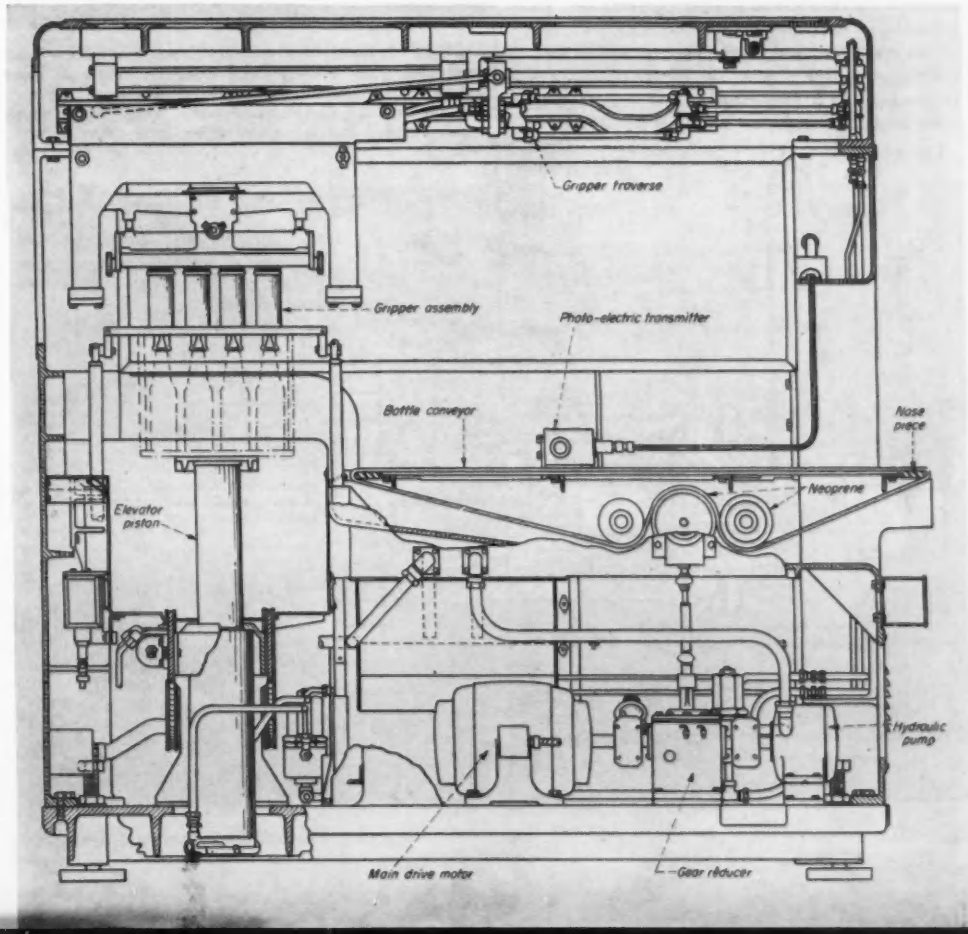
SOLENOID HYDRAULIC VALVES at the driven end of the case conveyor are actuated by the electric sequence system to control the elevator. The lower valves actuate the piston up and down at speeds controlled by the units above.

MOVING PARTS of the hydraulic-powered case elevating and gripper carriage traverse systems are shown in color in the diagram at the right. The bottle conveyor is driven by the main drive motor through a bevel gear and a gear box reducer unit. The mesh-belt bottle conveyor snubs over a heat-treated Ryalloy nose piece, used instead of a pulley to give minimum turning radius and eliminate dead plates for transfer to the next conveyor. The first experimental model of the new unpacker consisted of a case positioner, a case ejector, a gripper mechanism, a sliding plate transfer table, a peal-off stop to hold bottles as transfer plate was pulled from underneath, and a bottle conveyor—all mechanically operated. Research and tests showed that: (1) Case flow must be timed to the machine cycle; (2) A positive force, not gravity, is necessary to strip the bottles from the case; (3) A sliding table causes jamming of the bottles on the discharge conveyor; (4) A 48 bottle per case capacity is needed; (5) New processing lines required increased case speeds; (6) Customer's plants required straight-through, end-wise case travel; and (7) Machine elements in an all-mechanical unloader would be expensive, special designs, subject to rapid wear. The final hydraulic design meets these requirements and corrects faults in a simple, flexible machine.

GRIPPER UNITS are composed of two spring loaded steel fingers in a steel finger frame held in a die cast adjusting block which rides between the gripper rails.



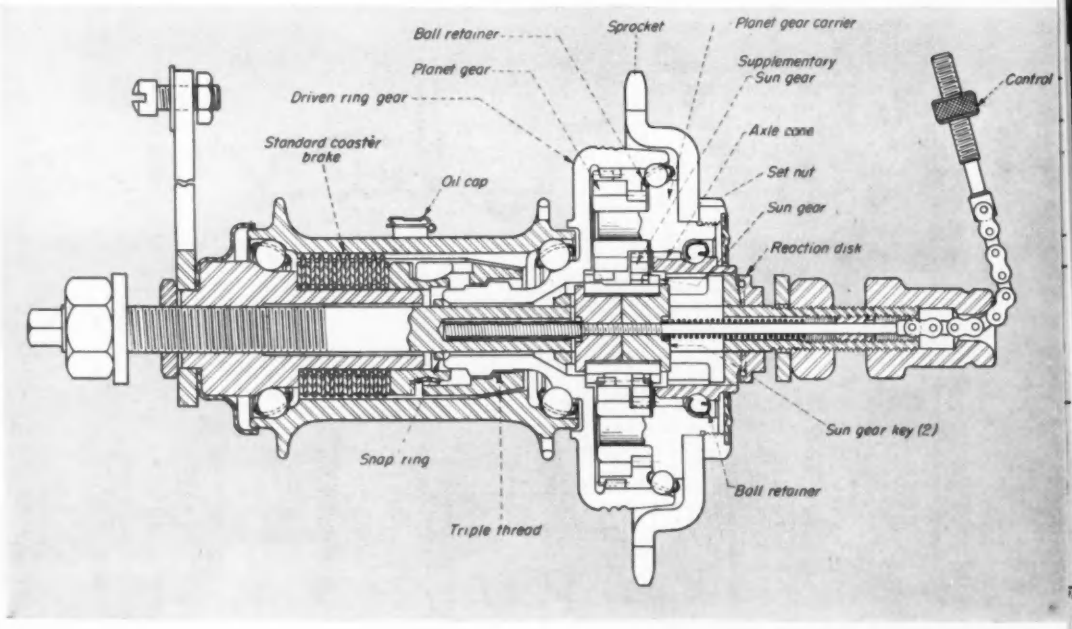
FLEXIBLE HYDRAULIC LINES feed the gripper cylinders riding on the carriage. The limit switch is actuated by the carriage to release bottles on the mesh conveyor.

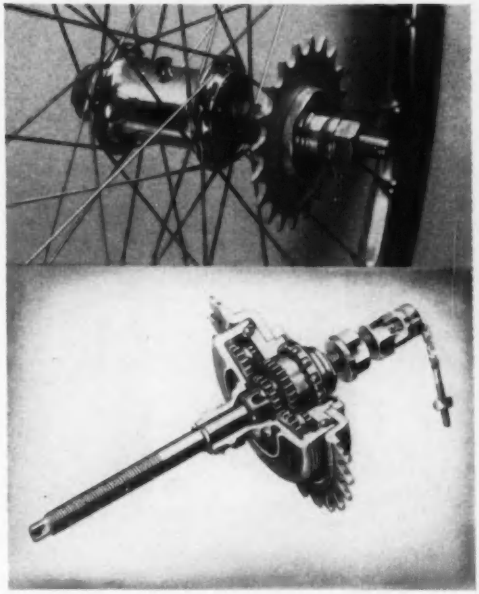


Planetary Gears Save Space in Coaster Brake

The Triplespeed Coaster Brake was designed by the engineers of the New Departure Division of General Motors to give greater bicycle pedalling ease by means of a compact, 3-speed transmission that is hand controlled and can be installed by a simple substitution on existing bicycles. A small, compact planetary gear train was hit upon as the sturdiest design incorporating synchromeshing of gears and allowing retension of the standard back-pedalling brake. The requirement of preselection of gears is met and ratios can be changed at any time by means of a shifting control lever adjacent to the handle bar grip. This design allows shifting without removal of the rider's hand from the steering bar. The transmission is 4⅞ in. long overall within the spread of the rear forks, and can be used on any balloon-tire or lightweight bicycle. The bicycle travels 14 ft. in low gear, 18 ft. in normal, and 24 ft. in high for every complete revolution made by the pedals.

EASY CONVERSION of standard bicycles to the new three-speed brake unit was a primary design requirement. There are no ratchets, pawls or complicated mechanisms to make assembly difficult. The standard coaster brake is removed and the Triplespeed unit substituted in the same wheel hub.

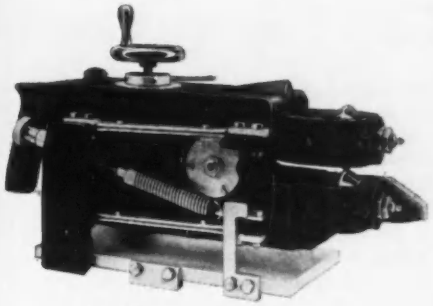


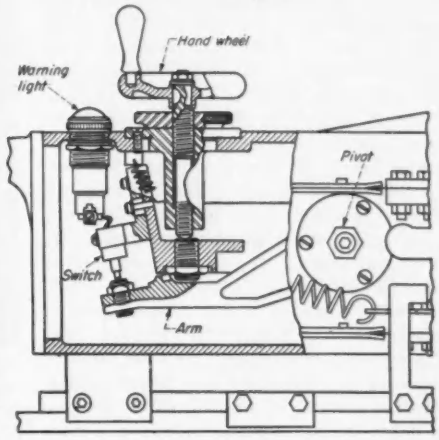


INSTALLATION is accomplished by removing the regular wheel sprocket and installing the new unit, which contains all the speed-changing gears in a single weather-proof case and sprocket and fits into the hub thread connection. The gear ratio is changed by pulling on the control cable.

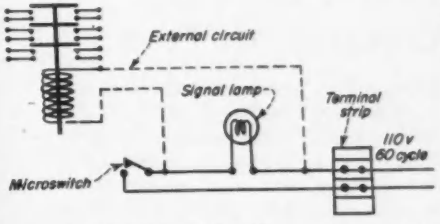
SUN GEAR ROTATES FREELY in low gear, one set of teeth meshing with the large planet and the other with the supplementary sun gear whose teeth mesh with the smaller planet gears. The mechanism is locked and drive is direct. For normal drive, the sun gear slides outward, unclutching from the supplementary sun gear and meshing with the internal teeth of the fixed axle cone. The large planet gears revolve about the stationary sun gear, causing the ring gear to turn. For high, the sun gear moves deeper into the fixed axle cone, meshing with the internal teeth of the supplementary sun gear and allowing the small planet gears to revolve about the outside teeth. The large planet gears drive the ring gear. There is no clashing, since the sliding sun gear is free of one set of mating gears before engaging another. The design ensures that the moving gear, regardless of speed, always finds its mating gear without lost motion. The position of the sun gear is directed by two separable keys located on each side of the sun gear and backed by two springs within the axle. With the sun gear under torque from the pedals, the shifting lever is moved to the desired ratio to position the sun gear key. When torque is removed by momentarily stopping pedal movement, the axle spring moves the sun gear to the predetermined position. Selection of any gear can be accomplished while driving by moving the lever on the handle bar to the desired position.

Pivoted Roller Simplifies Circuit





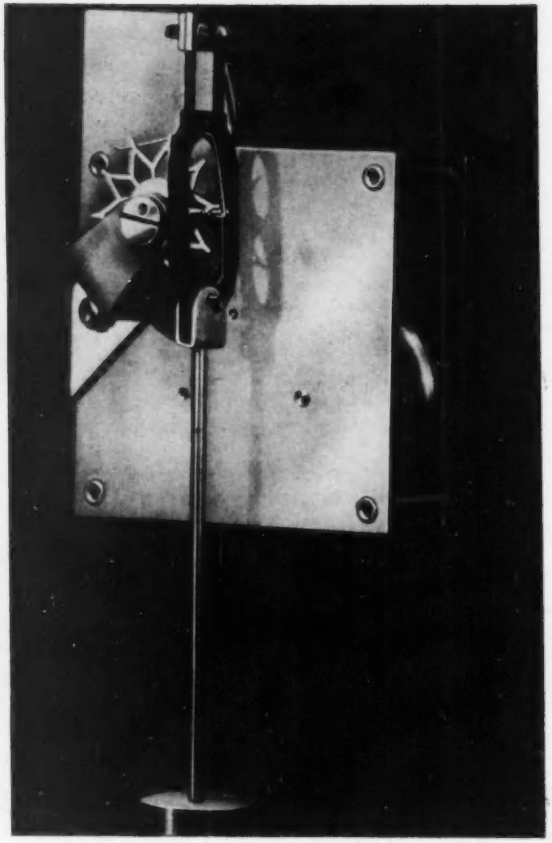
CONTINUOUS LIMIT GAGE was designed by Pratt and Whitney Division of Niles-Bement-Pond Co. to warn on over-thickness die sheets. Metal passes continuously through rollers.



SIMPLE CONTROL CIRCUIT includes precision switch, operated by pivoted arm attached to movable top roller to allow rigid support of components for long-life operation and precision control.

British Magnetic Clock Escapement Cuts Friction Loss

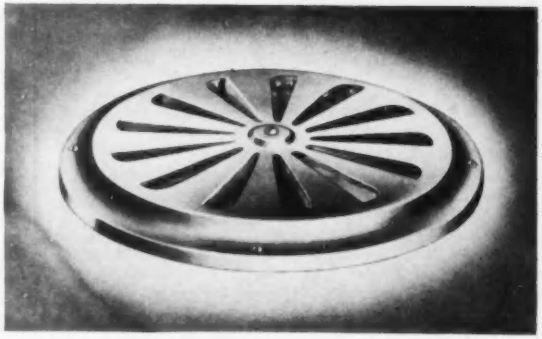
The scanning principle is applied to clock escapements in a new magnetic device invented by C. F. Clifford and developed by Horstmann Clifford Magnetics, Ltd., a subsidiary of the Horstmann Gear Co., Ltd., of Bath, England. The E. Ingraham Company has the exclusive rights to this invention for the United States and Canada. In simplest terms, a magnet is rotated by a clock train, scanning an armature in the form of a sine wave carried on a pendulum. A series of varieties is available for both pendulum clocks and transportable time pieces. The main virtue of the sine wave is that when applied in this way to lead the pendulum it complies with the harmonic law, giving a force that is proportional to the natural speed of the pendulum at each point. Since there is no mechanical contact between the magnets and the pendulum, no wear is encountered and no lubrication is required. High efficiency of energy transfer, as compared to that of the mechanical escapement, allows a reduction in the driving force, which may be accomplished by decreasing the size of wheel works or by increasing running time. The magnetic escapement does not require the precision of its predecessor and manufacturing costs and time can be lowered considerably.



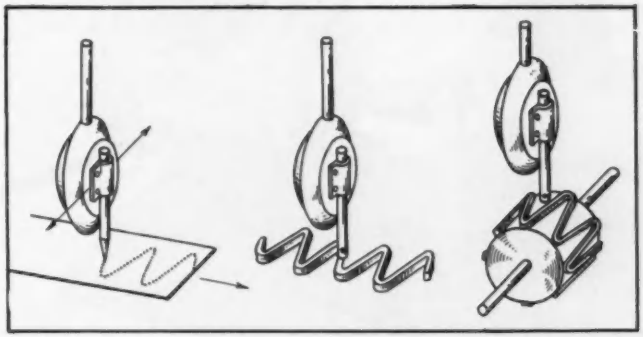
PENDULUM receives magnetic force from the wheel which turns at a constant rate, in synchronization with the pendulum. The horizontal velocity of the wheel edge equals that of pendulum.

Simple Diffuser Controls Air Flow

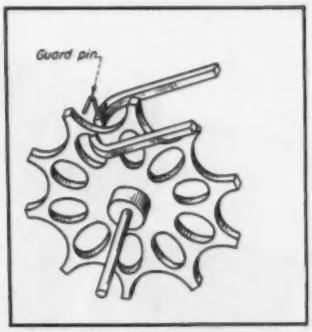
Simple control operates all functions of a ceiling diffuser developed by J. M. Marr, of the Aladdin Heating Corporation. An ingenious design allows air in variable volumes to be introduced into a room at any angle from horizontal to vertical flow. The face plate deflector and damper are circular plates with radial slot ports. On the face plate, the slotted pieces are folded back to act as deflection fins; the other plates are completely blanked out. Air volume is regulated by the adjustment between plates.



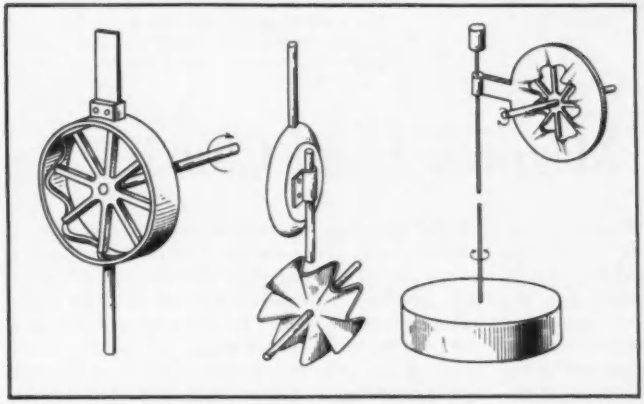
SUPPLY TYPE DIFFUSER DEFLECTOR PLATE has a series of indentations on inner side that can be reached by the fingertips through face plate slots to turn the deflector-damper.



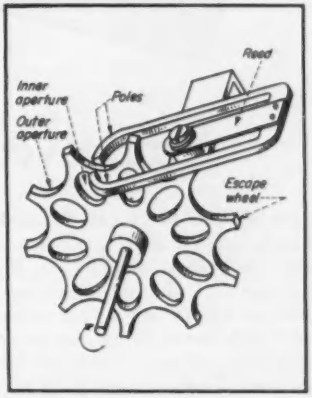
SWINGING BOB traces a sine curve on a moving paper. A mild steel strip, rotating under a magnetic pendulum pointer will, if an approximately correct torque is applied to cylinders, hold cylinder at speed dictated by pendulum.



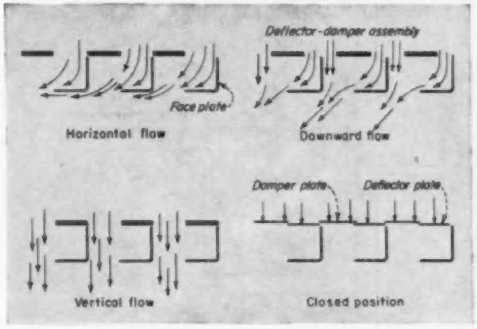
GUARD PIN oscillates over outer contour of wheel in refinement to guard against heavy shocks to reed.



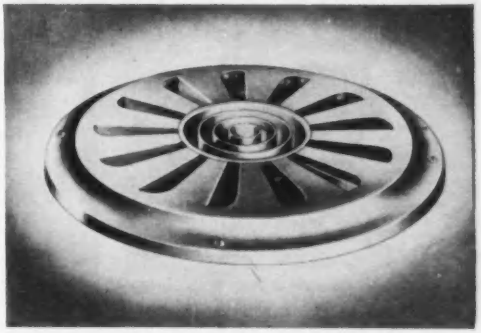
VARIATIONS OF PENDULUM and elastic shaft timing arrangements. Clearance between working parts is 0.005 to 0.020 in., depending on materials, with tolerances of 0.002 in. allowable. Common material is cobalt steel.



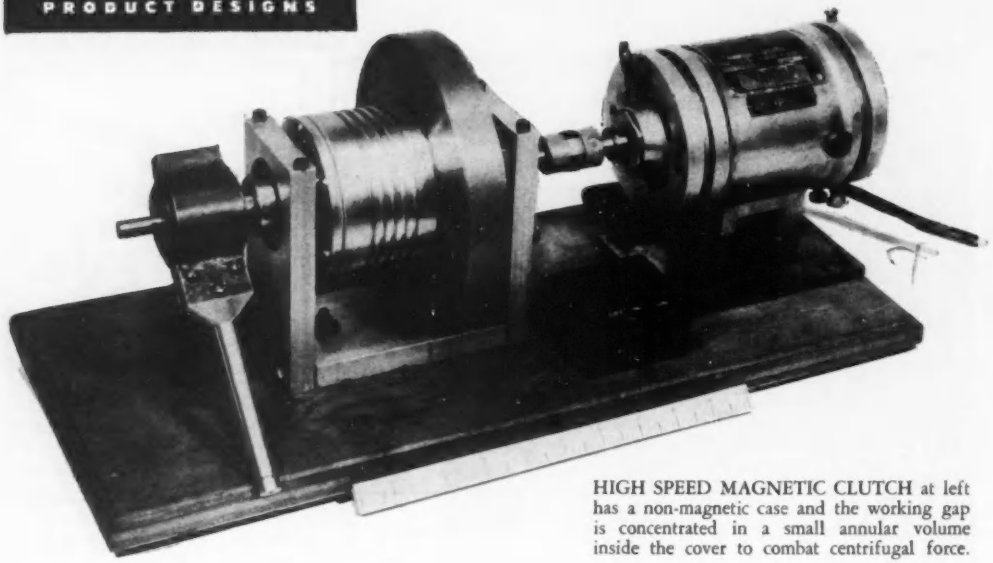
TRANSPORTABLE escapement allows wheel to turn so reed vibrates around apertures at its own frequency.



DIRECTION OF AIR FLOW can be varied from full horizontal to full vertical by moving locked deflector and damper plates, while face plate is held stationary.



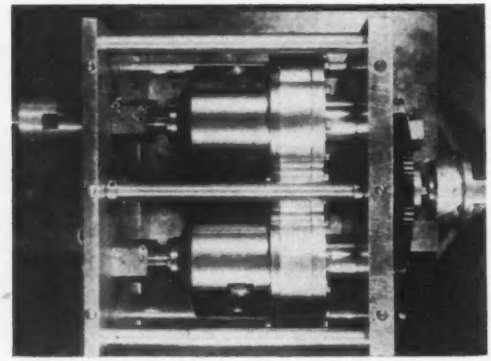
SUPPLY AND RETURN TYPE DIFFUSER is manufactured on same principle. The deflector and damper plates are locked by a setscrew to turn together.



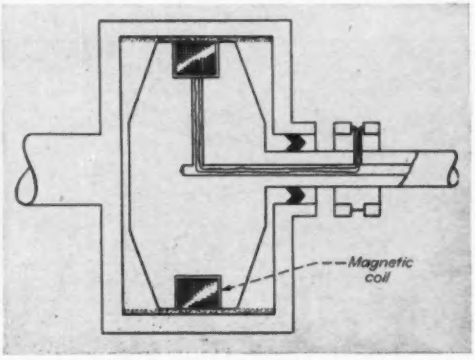
HIGH SPEED MAGNETIC CLUTCH at left has a non-magnetic case and the working gap is concentrated in a small annular volume inside the cover to combat centrifugal force.

Improved Magnetic Fluid Clutch

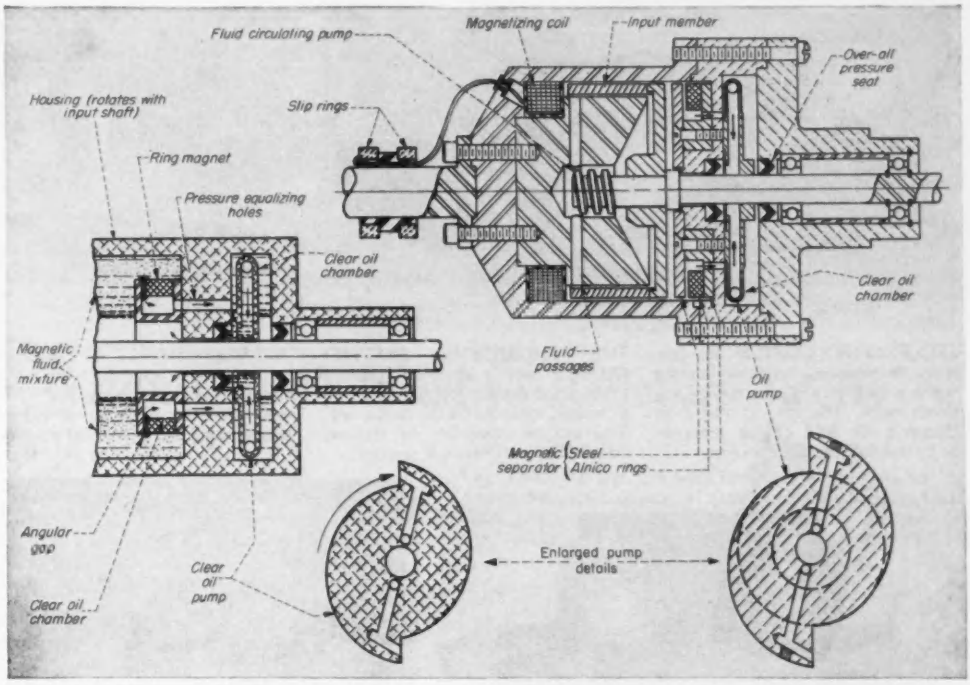
The National Bureau of Standards Magnetic Fluid Clutch design is characterized by ease of control, high efficiency, smooth operation, long life and simplicity of construction. Since this clutch was developed by the NBS in 1948, its unique features have been the subject of extensive investigations and new information on heat dissipation, sealing and powder settling has been of use in recent designs. Invented by Jacob Rabinow of the Bureau staff, the clutch is based on his discovery that frictional forces between solid surfaces and certain types of fluid media can be controlled by the application of magnetic fields. In its simplest form the device consists of two parallel magnetic plates separated by a fine magnetic powder. A magnetic field will bind the plates against movement parallel to their surfaces. The particles may be finely divided iron, which is mixed with oil, graphite or other dry lubricants, on most applications to reduce packing and wear. About 300 mixtures have been tested to date. Extensive development has been done on high-speed and hermetically sealed clutches.



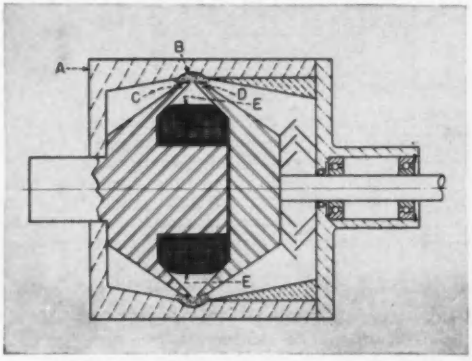
SERVO MECHANISM embodies two magnetic fluid clutches, using a new hermetic seal. Clutches sealed in this manner operated at 120 to 1,440 rpm at 0 to 200 percent slip for 30 days without visible particle leakage.



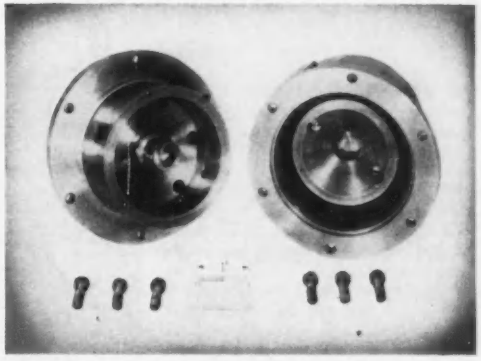
COAXIAL-CYLINDER TYPE CLUTCH minimizes centrifugal force on particles by using iron powder in working gap between cylinders. The centrifugal forces are overcome by magnetic forces at moderately high speeds.



HERMETIC SEAL was developed by NBS. Clear oil from a reservoir is continuously pumped along the shaft into the interior of the clutch. The clear oil is then returned to the reservoir through a magnetic separator which prevents passage of the iron particles. A second seal operates entirely in clear oil. A pump shown at the center of the output member in the view at right mixes the magnetic fluids and aids in the transfer of heat. Dissipation of heat produced by slippage is one of the most serious problems in any clutch. While air or liquid cooling can be used in the magnetic fluid clutch, special devices such as heat exchangers have been used satisfactorily. Improved seals allow high operating temperatures with the resulting improvement in heat dissipation. If a liquid lubricant is used with the magnetic powder, the mixture itself can serve as a cooling medium when the clutch is demagnetized. Use of solid lubricants such as graphite enables clutch to operate at higher temperatures and eliminates many sealing problems associated with liquids. Higher operating temperatures facilitate heat dissipation.



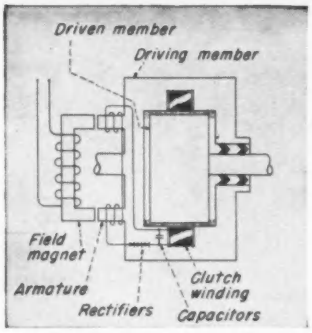
HIGH-SPEED CLUTCH has an outside case of nonmagnetic material, and the working gap is concentrated in the small space B, external to poles C and D of driving and driven members. The clutch is excited by the coil E.



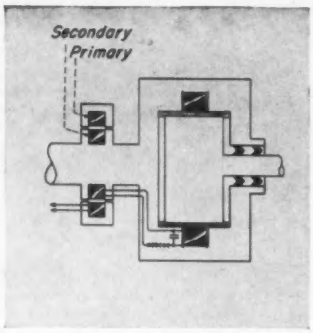
PARTIALLY DISASSEMBLED VIEW of a fluid clutch shows the open cylinder at left which acts as the output member. A pump in the center of the output member mixes the magnetic fluids and aids in the transfer of heat.

(Continued on next page)

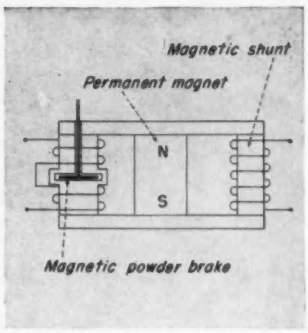
Magnetic Fluid Clutch (continued)



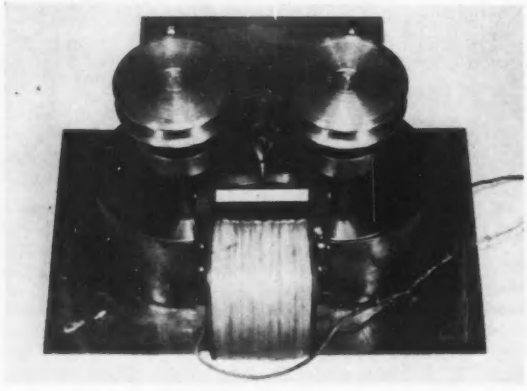
SELF-EXCITED CLUTCH has generator to produce alternating current, which is rectified and sent through the clutch coils. The field is varied by changing the field of the generator or by moving the field magnet.



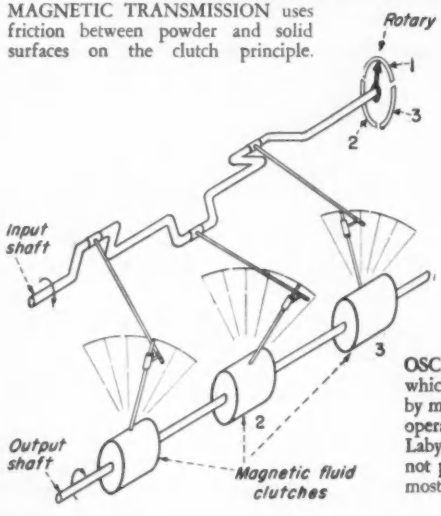
THE TRANSFORMER EXCITED CLUTCH uses a stationary primary structure to induce current into the secondary, mounted on the clutch. Settling can be minimized by residual magnetism or thixotropic greases.

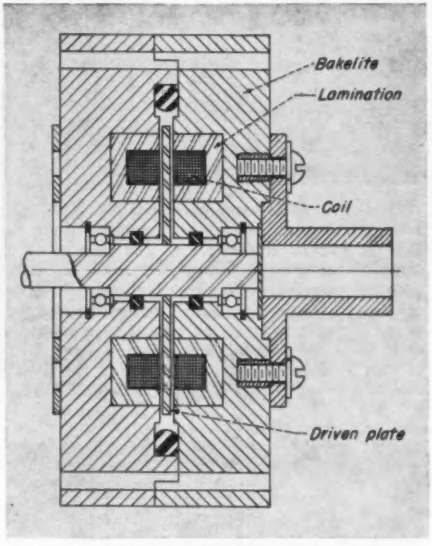


TWO-WAY SHUNT SYSTEM of powder brake is based on NBS clutch principle. Current shunts flux away from the brake, releasing it without demagnetising the permanent magnet. It is not released by power failure.



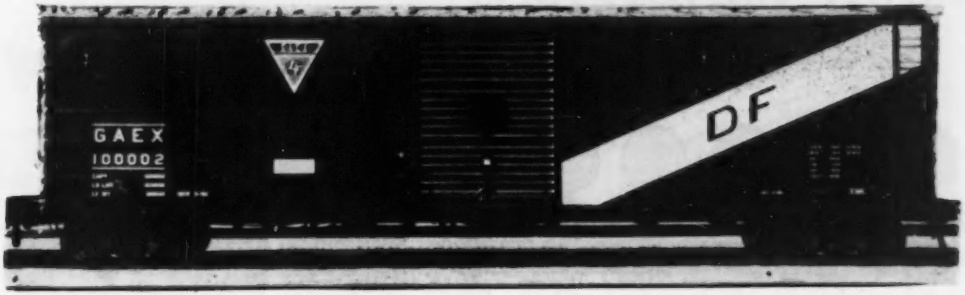
MAGNETIC TRANSMISSION uses friction between powder and solid surfaces on the clutch principle.





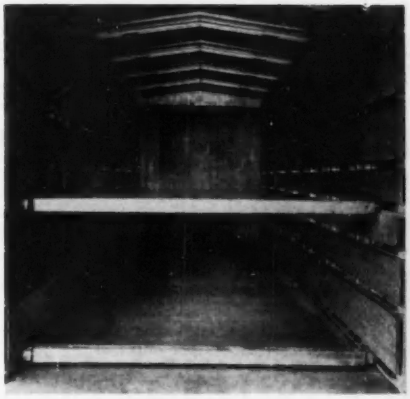
FAST-ACTING CLUTCH obtains a very short response time by laminating the magnetic structure. This time depends almost entirely on the response rate of the magnetic circuit rather than on the action of the ion particles. Magnetic circuit response, a function of inductance and source voltage, is speeded by reducing eddy currents by structure laminations.

OSCILLATING VARIABLE-SPEED TRANSMISSION, in which rotation is transformed to oscillatory motion and then, by means of clutches, to rotation, uses fluid clutches for smoother operation. The proper clutch is energized by the rotary switch. Labyrinth seals are effective on clutches at high speeds, but do not prevent temperature breathing, and hermetic sealing appears most desirable. Thick grease lubricants also simplify sealing.

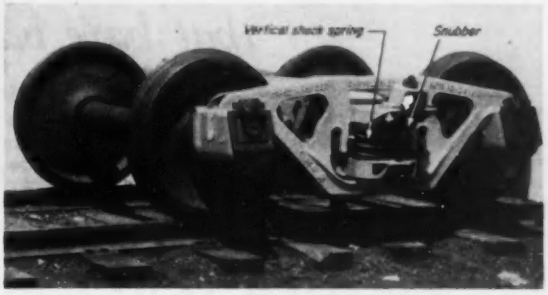


Box Car Tailored to Railroad Needs

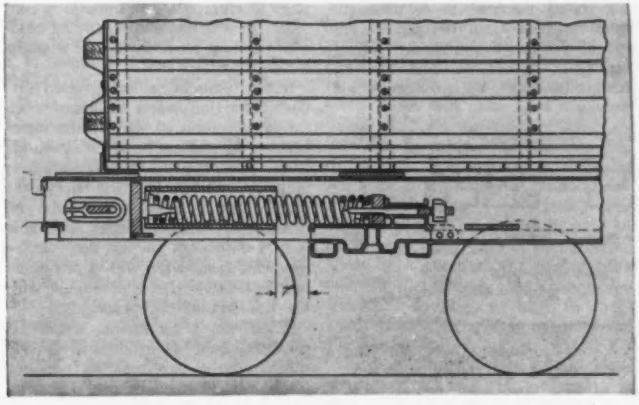
The GAEX-DF box cars were designed by the General American-Evans Company of Detroit to reduce railroad claim losses from damaged material and to increase pay-load capacity and average miles traveled per day.



DAMAGE FREE LOADER to restrain the load in transit consists of 40 cross members, 10 deck boards, 10 bulkheads and 8 door rails. The cross members engage the belt rail with a spring lock.



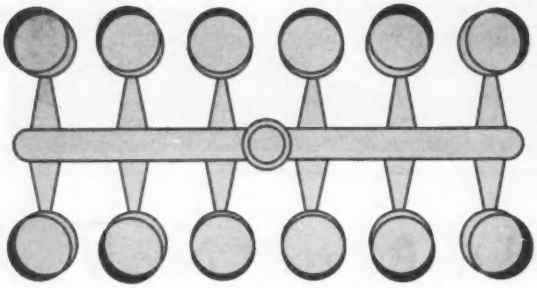
TRUCK, designed by Chrysler, carries swing hangers on two links adjacent to the bolster. The snubber controls vertical motion not taken by $3\frac{11}{16}$ in. springs. Lateral shocks are absorbed by pendulum action of self-aligning spring hangers to increase load protection.



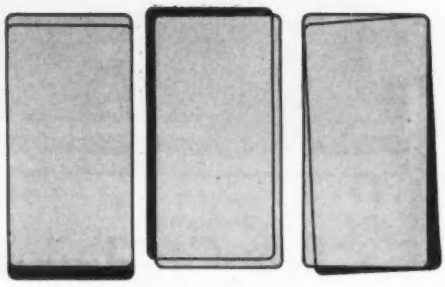
CUSHIONED UNDERFRAME reduces end shock. It includes all-welded, single spring, underframe to protect car and load from horizontal impacts, with 7 in. travel, compared to the conventional $2\frac{3}{4}$ inches. Cushioning capacity of 36,000 ft lb is developed. Steel floor, used for corrosion and damage resistance, is welded to the side sills and 4 Z section stringers, 2 on each side of the center sill. In addition to the standard angle side sill, a continuous 8 in. channel extends from end sill to end sill to fortify the 8 ft clear door openings, provided for fast movement of power lift trucks. Post spacing of 3 in. Z section side posts is 2 ft, 8 in., considerably less than the existing railroad standards.

FOUR CONDITIONS

affecting dimensional accuracy of



1. DIFFERENTIAL THERMAL EXPANSION



2. LATERAL MISALIGNMENT

. . . KNOWLEDGE of the reason that have been found satisfactory

THE DEGREE OF DIMENSIONAL ACCURACY that can be attained in die cast products is in part goverened by the mechanical limitations inherent in the process, but in greater measure is dependent upon the experience and forethought of the product engineer.

Some sources of dimensional instability are inseparable from the die casting process. Provision has to be made for the escape of air ahead of the advancing metal. Also in commercial practice there is usually a gap of 0.002 in. to 0.006 in. or more between the two die members. Slight lateral displacements of the two die members are also frequent, although these are usually small. Errors arising from lateral displacement tend to increase towards the end of a long production run due to wear on the guide pins that register the two die members. They occur earlier, and are more dfficult to correct when the parting line is stepped, for flashed metal frequently lodges unseen between the two rubbing faces and causes galling of the surface.

Lateral misalignment caused by wear may be transverse, oblique or angular, as shown in the heading illustration. Also, small components produced in large multi-cavity dies occasionally are inaccurately formed due to misalignment resulting from unequal expansion of the two die members. While this fault cannot be remedied by changes in design, greater dimensional precision can be attained when using two-or four-cavity dies on small fully automatic machines operating at up to 1,750 cycles per hr than is possible using ten- or twelve-cavity dies on larger and slower machines.

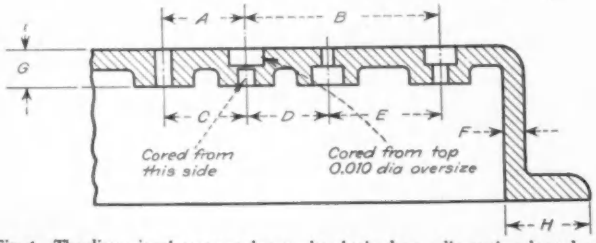


Fig. 1—The dimensional accuracy that can be obtained on a die casting depends on the dimensions involved. Standards for each of these dimensions vary, see text.

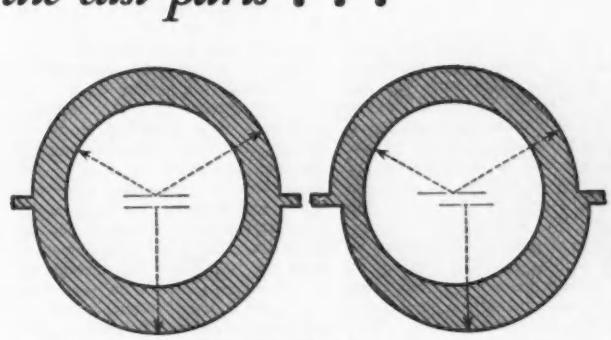
Designing to Decrease Misalignment

The extent to which misalignment can be expected to occur under normal production conditions and with various die casting alloys is tabulated in the Reference Book Sheets, pages 169 to 171. Here it will be enough to consider the steps that the product engineer can take to minimize the effect of misalignment.

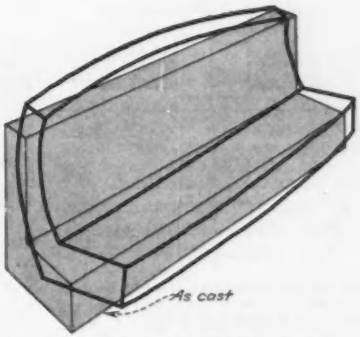
First it should be remembered that flash formation is at a minimum when the mating faces of the two die members are flat and can be surface ground; if the parting plane is irregular, it is more difficult to match the two blocks exactly and a heavier flash may be formed. A salient design principle is to profile parts so that they can be produced from a die with a one-plane parting face, if this is consonant with the function of the product.

Then too, a die casting should be regarded as if its inside and outside surfaces were two separate parts or shells, each formed by one die mem-

die cast parts . . .



3. WEAR OF REGISTER PINS



4. DISTORTION ON COOLING

for variations and of average limits will aid the designer in . . .

Establishing Tolerances for Die Castings

H. K. BARTON

ber. Considering either of these shells separately, dimensions between centers or locating faces can be held within close limits—±0.002 in. over a wide range of work, or as tight as ±0.0005 in. in favorable instances. Dimensions taken between the two shells, however, as *F*, *G* or *H* in Fig. 1, depend on the registration of the die blocks and are subject to variation. This variation is always positive on dimensions like *G*; that is, +0.003 to +0.006 inches.

Next, it is necessary to consider the dimensional variations in the center distances between holes formed in one or the other of the supposed shells. Each hole can be represented as a bush secured to one of the shells, corresponding to that side of the die from which it is cored. No significant variation occurs in such dimensions as *B* when the center distances are between holes cored from the same die member, but the accuracy of dimensions such as *E* depends on maintaining precise registration of the two die blocks, and can therefore be expected to vary during the production run. Cored holes that must have a precise relationship to one another must accordingly be cored from the same side of the die. This presents no difficulty when the cored holes are of one diameter right through the casting, but sometimes close limits must be held on dimensions like *D*, taken between two holes with counterbores on opposite sides of the casting. The counterbore should be cored up to 0.010 in. oversize to allow for misalignment of the die blocks.

Similar considerations are necessary when concentricity of external and internal features is important. If, for example, a disk-like die casting—or a similarly shaped piece forming part of a large casting—is to be cored, the cavity and the core are likely to be slightly eccentric if they are on opposite die members (Fig. 2) but will show no significant variation when constructed in the same block (lower sketch). Concentricity becomes a major factor when the part to be produced is thin: in a small die cast cap having a mean wall thickness of 0.015 in., the relative displacement of the core and cavity members by 0.001 in. results in a wall thickness varying between 0.014 in. and 0.016 in.—more than 12 percent.

The dimensional accuracy with which a hole can be cored from one side of a casting to the other varies directly as the diameter and inversely

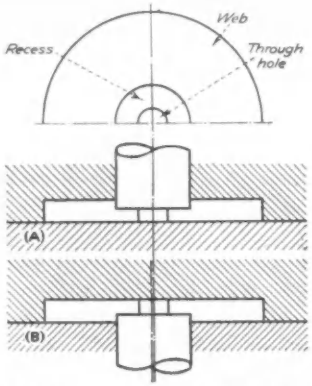


Fig. 2—If concentricity is to be held to ± 0.001 in. or closer, all critical diameters should be formed in the same die member at A. Some degree of lateral float is inevitable if the design of the part necessitates the construction at B.

as the length of the core, as a rough guide, and for any given diameter there is a limit on the depth that can be satisfactorily cored, Table I. This latter value depends on the alloy being cast, and is lower for blind holes than through holes. Highest accuracy is obtained when holes are cored from each end, and are supported in the center. Holes passing right through the casting can often be formed by cores anchored in the opposite die member, and although misalignment between the die members may cause the hole to deviate by perhaps ±0.002 in., this is considerably less than the run-out if the holes were drilled.

Blind holes of small diameter, on the other hand, are likely to be affected by the thrust of the inflowing metal upon the unsupported end of the core. The degree of displacement to be allowed for at the bottom of the hole due to "core weave" is given in Table II. Positional errors on deep holes from this source are so much greater than those for through holes of the same diameter that it is frequently better to core a hole right through the casting if the open end can be tolerated.

At the other end of the scale, troubles are often encountered with large diameter holes cored in thin section. These do not become serious until the wall thickness is reduced to 0.060 to 0.040 in. in the case of zinc alloys, when it is possible that the hole periphery will be out of round on one side. This is because very thin sections have to be cast under extremely high pressure to prevent premature chilling, and the flow of the metal around the core is so rapid that it cannot hug the surface on the side away from the point of influx. As a result, the hole is not perfectly round, but of a teardrop shape. This difficulty need not arise if the designer provides a bead around the cored hole on one or both paces of the casting, the locally increased section then reducing the speed of flow and allowing the streams from each side of the core to join up without any visible weld. An alternative method is to omit the core and pierce the hole in a subsequent operation.

The greatest dimensional accuracy is attainable when, as in all the instances so far examined, the component can be produced from a simple two-part die with all holes and recesses formed by fixed cores, Fig. 3. Highest production speeds, and hence lowest costs, are also associated with this type of construction, so that it is advantageous to go over every projected design at an early stage and eliminate all overhangs and undercuts that would prevent a straight draw from a two-part die. If, in addition, all holes are at right angles to the parting plane, the cores forming them can be fixed. Should any of the holes be set obliquely, on an arc or parallel to the parting-plane, the cores forming them must be retractable, and as such cores must move freely in their housings, dimensions measured between them are subject to greater variation than is the case with fixed cores. Table III gives dimensional requirements for rocking cores.

When a part has large external undercuts, these must be formed by independent die elements suitably mounted in one or the other of the main blocks; dimensions taken between two fixed location faces in the same die element can then be held to close limits, but fairly wide tolerances must be scheduled for dimensions taken between a location on the sliding block and a second located in one of the main die members or another moving element. The allowance to be made varies with the nature of the moving elements and according to whether the dimension is taken across the parting-plane.

It is easier to maintain accuracy between moving cores than between sliding blocks; this results from purely mechanical considerations. Most cores are of circular section, but even when they are not, it is usual practice to machine them with circular shanks so that their housings in the die can be bored and ground. Sliding blocks, on the other hand, are commonly rectangular and are retained by keys in the milled slideways cut in the face of one of the die blocks. In addition to the difficulty of obtaining as good a fit as in cored housings, wear is greater on the limited surface of the keys and maintenance is less readily carried out.

Effect of Section Size of Accuracy

There is an optimum section for every casting, Table IV, depending upon its overall size, castability of the

Table I—Recommended Dimensions for Cores

	Alloy					
	Tin	Lead	Zinc	Alumi-num	Mag-nesium	Cop-per
Limiting core length square of mean core dia x factor given						
Core unanchored	12	10	10	6	6	4
Core anchored (S)	16	15	15	8	8	5
Min. dia (T), in.						
Core fixed	0.025	0.025	0.025	0.050	0.050	0.100
Core moving	0.030	0.030	0.040	0.065	0.065	0.125
Min. taper on core (V) in., per in. of dia or length	0.002	0.002	0.003	0.008	0.008	0.020
Min. draft on cavity wall (w) in. per in. of depth	0.005	0.005	0.003	0.008	0.008	0.020

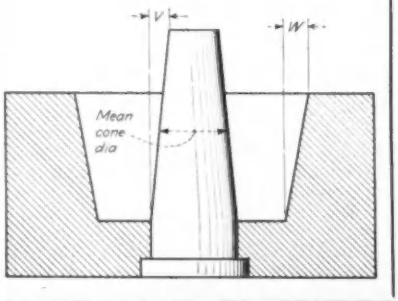
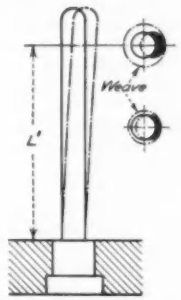


Table II—Allowance for Core Weave in Blind Holes



Alloy	Allowance*
Tin Lead	(L'/d x 0.002)
Zinc	(L'/d x 0.0025)
Aluminum Magnesium Copper	(L'/d x 0.005)

* L' = free length of core to required height; d = diameter

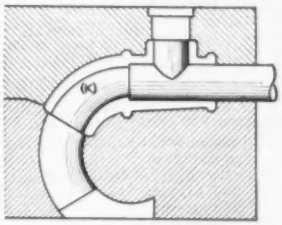
alloy and, in some degree, the complexity of the contours over which the molten metal must flow. This last factor is of less importance than might appear, and an analysis of some thousands of satisfactory castings over a period of ten years led the author to the empiric formula: wall thickness = $K(3\ S)$, where S is the true external surface area (not the projected area) and K is a constant for each alloy group equal to some few thousandths of an inch. For the zinc alloys it can be taken as 0.020 in. Thus, for a flat plate 8 in. by 8 in. the optimum wall thickness is around 0.080 in. and for a box 6 in. by 4 in. by 2 in., it is the same. A vending machine cover 32 in. by 8 in. by 4½ in. substends an external surface area of 616 sq in., of which the cube root is 8.5 and the optimum section thickness consequently 0.170 in. when cast in a zinc-base alloy. This accords well with the experimental results recorded when the die for this part was made with an over-size core which at first gave a wall thickness of 0.050 in. (when only cold-shuts were produced) and which was gradually machined off to increase the wall thickness until the castings filled out and were of satisfactory surface finish. Where the inside of the casting can be generously ribbed in the direction of metal flow, the wall thickness can often be reduced to two-thirds of the value given by the formula and still yield castings of consistently good finish, but this is applicable mainly to the upper end of the size range. In castings with wall thicknesses below 0.032 in. ribbing is inadvisable, since the metal flow travels preferentially along the deeper channels of the ribs and airlocks tend to form in the intervening spaces.

The maximum section thickness for die castings in any alloy is about ⅝ in. While sound castings of thicker section have been produced, the cooling period is so long that it is a better proposition to cast the part in two stages if the required section thickness is greater than half an inch. The method is illustrated in Fig. 4, where the shaded central portion is a precast insert placed in the cavity and located upon the core pins. On injection it is completely enveloped in a ⅛ in. thick skin which gives the required contours to the part. The die cavity from which the insert is produced need have only a rough machined finish, and the completed die casting, besides being free from porosity, is produced in less time from this two-stage process than would be needed to cast it in a single operation. Two-stage die casting can also be used on occasion to produce parts otherwise impossible to manufacture commercially.

Other Effects of Alloy on Accuracy

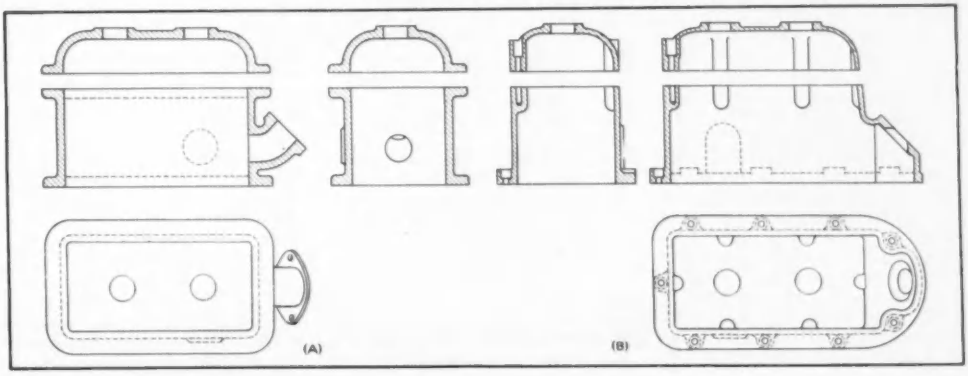
The choice of an alloy for die casting is seldom wholly dictated by the precision with which the product can be manufactured. More usually it is

Table III—Dimensional Requirements for Rocking Cores



Alloy	Dimensional Requirements		
	Min. dia, in.	Max. curvature, deg	Taper/In. Mean length, in.
Tin Lead	0.150	75	0.004
Zinc	0.310	60	0.006
Aluminum Magnesium	0.375	60	0.012
Copper	0.560	60	0.032

Fig. 3—Valve housing as a sand casting (A) and redesigned for die casting (B). In the die casting, the top flange has been dispensed with, the cover flange reduced in width, the pipe mounting flange made an integral part of the body, and other changes made so that a two part die could be used, thus permitting closer tolerances



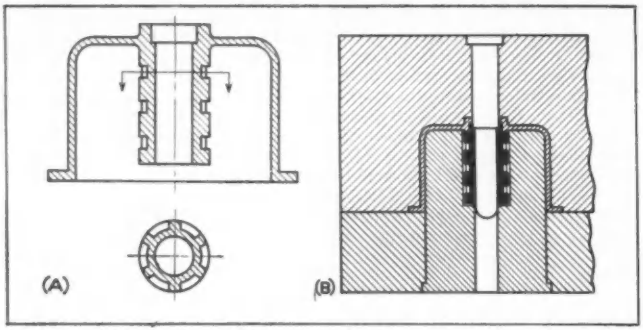


Fig. 4—How inserts can be used to reduce casting complexity: (A) housing impossible to die cast or machine with any degree of precision; (B) same housing, with a die cast insert for the center section, can be cast without difficulty due to undercuts.

Table IV—Wall Thicknesses for Die Castings

	Tin	Lead	Zinc	Aluminum	Magnesium	Copper
Maximum wall thickness over large areas, inches	....	....	0.5	0.5	0.4	.....
Locally thickened sections not to exceed adjacent wall by more than factor given	....	....	4	3	3	.....
Minimum wall thickness over large areas, inches	0.060	0.075	0.045	0.075	0.080	0.100
Minimum wall thickness over small areas	0.030	0.040	0.015	0.045	0.050	0.060
Preferred section = cube root of external surface x factor given						
Surface plain	0.030	0.030	0.020	0.040	0.045	0.060
Surface ribbed	0.020	0.020	0.015	0.025	0.030	0.030

strength, surface finishing characteristics, lightness, corrosion resistance or some combination of physical properties related to the functions of the projected die casting that determines the alloy group that will be chosen.

However, here we are concerned primarily with the physical properties of the different alloys only insofar as they affect dimensional accuracy, either directly or indirectly. Of first importance is the liquification temperature, for the dimensional accuracy of the casting, roughly speaking, varies inversely as the melting point of the alloy. Other thermal factors affecting production are solidification shrinkage and cooling contraction.

The melting-point of the alloy reacts directly upon the precision of the parts produced, for the higher the melting-point, or more strictly speaking, the temperature of injection, the shorter is the life of the die. A tin-base alloy, for example, has such a low heat input that sliding cores 0.875 in. in diameter will work smoothly for long periods if the clearance in their housings is no more than 0.00075 in. It is obvious that this promotes the holding of close limits on center distances between two such cores. A similar die for an aluminum alloy would require a clearance of at least 0.0025 in. on each core housing, for otherwise the cores would rapidly gall their seatings. Further, as the operating temperature of the die increases, the temperature differential between the two main blocks widens and fluctuations become more marked; expansion of the several die elements takes place at different rates and it becomes even more difficult to hold them in correct registration. Variations due to misalignment and wear on the register pins are quicker to appear and reach undesirable proportions much sooner.

Solidification shrinkage and cooling contraction both affect the dimensional accuracy of the product, but need to be considered separately. If the metal is injected above the liquidus temperature, as in practice is always the case, there is a slight shrinkage as the molten mass cools to the liquidus. This initial shrinkage has no effect upon the casting, since it is compensated by the forcing of additional metal into the cavity under pressure. Between liquidus and solidus, a larger contraction takes place, associated with the evolution of latent heat and the change of state of the metal. In very few instances does this contraction take place at the same rate throughout the cavity, for it is influenced by the surface volume ratio at various parts of the casting.

Solidification shrinkage is consequently completed in thin sections, while isolated thick sections are still fluid or plastic at the center. If the thick sections are remote from the gate, no additional metal can be forced in to compensate for the loss of volume, and internal voids or surface distortion result. When any part of the casting has reached the solidus temperature it continues to contract at a slower rate, this shrinkage in the solid state being distinguished as cooling contraction. Stresses are then set up within the casting, which cools under some degree of tension.

When the section thickness of the die casting is near the optimum value, only the briefest dwell period is required before ejection, and consequently there is little opportunity for internal stresses to affect the mechanical strength of the part. Ejection at a relatively high temperature, however, means that a considerable contraction takes place as the component cools to room temperature; a die casting in a zinc base alloy ejected at a temperature of 600 F, and with a nominal length of 10 in., will contract to 9.933 in. while cooling to 70 F. In practice, the contraction is smaller because the length of the cavity itself will have been measured at room temperature, and the die will have expanded while being raised to the operating temperature (for the zinc-base alloys, about 430 F).

Taking a chrome-vanadium die steel as standard, this expansion is roughly 0.026 in. on a 10 in. length. In cooling to room temperature, therefore, the die casting will shrink from 10.026 in. to 9.958 in. and so will measure 0.042 in. less than the nominal length. If the drawing size is to be held, the toolmaker must make the cavity 10 in. long (drawing size) plus 0.042 in. (contraction allowance). This assumes that no contraction at all can take place before the part is ejected; the standard contraction allowance for zinc alloys of 0.006 in./in. strikes a mean between free shrinkage and restrained shrinkage.

Bearing in mind the modifying effects of the cooling contraction and the partially compensating expansion of the cavity, it is possible to establish a relationship between the ac-

curacy with which the die is constructed and the precision with which the product can be cast. The toolroom of a responsible contract die caster will reckon to hold decimal dimensions to ±0.005 in. unless closer limits are definitely specified. If the part drawing gives a certain dimension as 1.750 in. the toolmaker will add contraction allowance and so lay out a nominal length of 1.760 in., with effective limits of 1.765 in. and 1.755 in., assuming that he is concerned with a zinc-base alloy and works on the standard contraction of 0.006 in./in.

This contraction allowance represents an average value, but in a casting of large size the actual shrinkage will vary according to the degree of restraint prior to ejection. It may range from 0.008 in./in. when there is no constraint to 0.004 in./in. when contraction is entirely prevented. In the former case the given dimension on the casting when cooled to room temperature will lie between 1.741 in. and 1.751 in., and in the latter between 1.749 in. and 1.759 in. The spread of the nominal 1.750 in. dimension is thus between 1.741 in. and 1.759 in., for it is often difficult to forecast when to use more or less than the average contraction allowance.

If the toolmaker works to closer limits, and holds his 1.760 in. dimension between 1.759 in. and 1.761 in., the uncertainty as to the precise shrinkage still remains the same. The spread of the nominal 1.750 dimension on the cooled casting is now from 1.745 in. to 1.754 in. with maximum and minimum shrinkage respectively. These are not the limits between which the castings will vary in production; in using the term "spread of the dimension" it is intended to convey that when the trial shots are made from the die any dimension having a nominal value of 1.750 in. will be expected to have an actual value, measured on the cooled casting, lying between 1.745 in. and 1.754 in. If the actual dimension of the cooled casting is found to be 1.748 in., 0.002 in. undersize, the die cavity must be opened up by that amount. It is so that corrections of this kind can be made after trial castings have been checked, that die casters normally try out a die before hardening. To facilitate the modifications, it is common practice to make cores slightly oversize and cavities a trifle small when building the die.

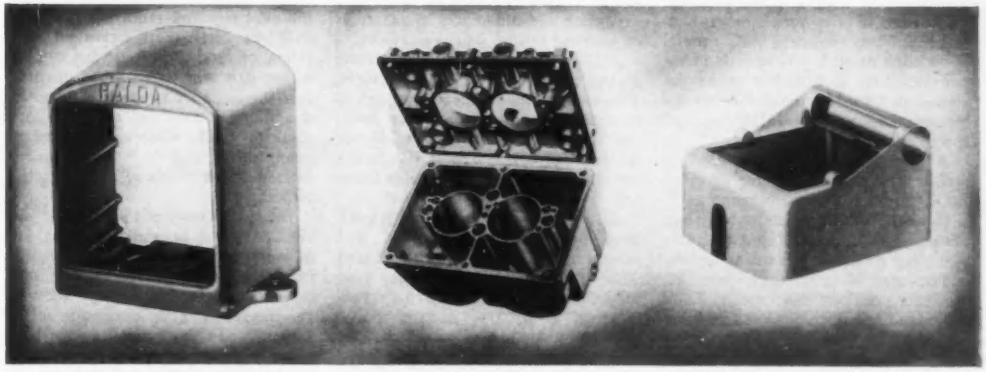
When the die has been modified and all dimensional errors corrected, there still remains one source of variation. This lies in the fluctuation of operating conditions during production. The die cavity, as was noted above, expands as the operating temperature rises, and for a difference of 120 F the expansion—or contraction—of a typical chromium-molybdenum die steel amounts to approximately 0.006 in. on a 10 in. length. Increasing the operating temperature of the die usually implies increasing the ejection temperature also, though not proportionately. This enlarges the cooling range to room temperature and so contraction is slightly greater, by about 0.001 in. for every 85 F on a 10 in. length. These dimensional variations resulting from fluctuations in operating conditions can be held in good practice to better than 0.0005 in./in. and so become of importance only on large die castings. On a 20 in. length, any dimension between two fixed points in one die member, once established, should not vary by more than ±0.005 inches.

Minimizing Variations for Assembly

In designing large die cast parts, it is necessary to make allowance for unavoidable variations, the effect of which will be principally seen in assembly operations. Coring out holes $\frac{3}{16}$ in. diameter or less is inadvisable when the holes are spaced more than 30 in. apart, as the slender cores are liable to be pulled over as the casting contracts, if long; while the holes may take an oval form if the cores are short. Screwed steel stud inserts of $\frac{1}{4}$ in. diameter or greater can be used successfully when spaced up to about 45 in. apart; at longer distances, the outermost inserts gall their housings during ejection. As the length of the casting increases, the clearance in mating parts through which the inserts pass must be increased also. Small uncored bosses which are subsequently jig-drilled and tapped should be somewhat elongated in plan or increased in diameter to allow for dimensional variation on center distances above 30 in. When integral rivets are used to assemble two large die castings, the rivets should preferably be formed on the deeper of the two parts; if on the shallow component, they are liable to be weakened by shear stresses as the casting contracts. These stresses are inhibited on the deeply cored part, where the massive core prevents any great degree of contraction before the rivets are clear of the die.

Another source of assembly troubles is the warpage that sometimes occurs on die castings of large size, but this can be prevented by careful design. Like many of the faults previously noted, it is at a minimum when the sections of the die casting are of even thickness and when sharp angles are avoided in the initial design.

Fig. 5—Three well designed castings. Left, meter housing with generous draft, which permits use of tapering internal assembly lugs. Center, complex casting designed with a flat parting line and for a minimum of moving cores. Right, housing with adequate support for cores forming the semi-tubular sections.



Gjuteriaktiebolaget Fundator, Stockholm — *Buhler Brothers, Switzerland* — *Gjuteriaktiebolaget Fundator, Stockholm*

Dimensional Tolerance System

For Molded Hard Rubber Parts

Cost of molded hard rubber parts as affected by close dimensional tolerances. A percentage tolerance system based on a consideration of the accumulated variables inherent in mold distortion, production processes and materials.

W. L. HARNEVIOUS
Design Engineer,
Stokes Molded Products, Inc.

MORE CAN BE GAINED IN COST SAVING by the proper use of tolerances when designing molded hard rubber parts than by any other one factor that can be controlled by the designer.

No standard tolerances are in general use today. A widely used practice is to place on drawings, as shown in Fig. 1, a general tolerance note such as "$\pm\frac{1}{64}$ in. for fractional dimensions and ± 0.005 in. for decimal dimensions." Since no relationship exists between such tolerances and the problems of molding hard rubber parts, this practice has no value as a tolerance system in their manufacture.

Designers and engineers who are not primarily associated with the molding of hard rubber can hardly be expected to have a detailed and complete knowledge of the problems encountered in this industry. A general knowledge of such problems is essential, however, if parts are to be designed that can be molded at an acceptable cost and yet fulfill required specifications.

A brief analysis of manufacturing problems will make clear the necessity for an intelligent use of tolerances.

Hard rubber is a vulcanized product composed of rubber, sulphur and various other materials and curing agents.

The cost of chemically pure ingredients prohibits their use in many compounding operations. The raw materials as obtained commercially, therefore, are of variable quality in spite of rigid laboratory controls. The compounding introduces more variables; and the molding pressures and temperatures some additional ones.

Molds are made with an accuracy limited by the machining operations required to make them. Furthermore, molds are subject to dimensional distortion under the molding pressures and temperatures. As tolerances become closer on the molded articles, the molds must be machined to closer than normal tolerances, and built stiffer to reduce distortion under the molding pressure. These refinements increase the cost of the mold.

All molds consist of two or more parts. The flash between these parts influences the accuracy of the molding. Additional tolerances, therefore, are necessary on a dimension that crosses the parting line or lines of the mold. Multiple cavity molds require wider tolerances than single cavity molds because of variations in thermal expansion and differences in quantities of material loaded into the cavities.

All the foregoing variables increase as the size of the molding increases. The thermal and chemical reactions in large masses often cause more deviation than is normally expected in the molding process. The final results can be controlled to certain limits only.

All hard rubber moldings shrink after discharge from the mold, and assume dimensions somewhat less than those of the cavity in which they were produced. This shrinkage may vary as much as ± 0.004 in. per in. of length in different pieces from the same mold and from the same compound. This variation of shrinkage is largely uncontrollable and is responsible for the individual deviations in dimensions of parts produced from the same equipment.

Any tolerance system, to be of value, must take into consideration the accumulation of these inherent variables in the production of molded hard rubber parts.

When closer tolerances are required than those obtainable in the normal molding process, additional operations must be performed on the piece after its removal from the mold. Depending upon the closeness of the tolerances, these operations may range from handling the part on and off a special shrink or cooling fixture to precision machining.

Almost any tolerance can be held if cost is not a consideration. If enough pieces are made and enough finishing work is done on them, of course, a certain percentage of pieces will pass the most rigid tolerances.

When cost is an important consideration, and the proper functioning of the part will permit, it is essential that the designer specifies a tolerance that permits uncontrollable variations resulting from: Compounds, presses, temperatures, and the human element of loading the molds and handling the pieces.

All these causes of dimensional deviations result in variations that are in proportion to the size of the molding. The only tolerance system that is workable, therefore, must allow a percentage of each dimension as a tolerance. To this percentage must be added a tolerance across the parting line or lines of the mold to compen-

sate for material flashed at these points.

The following rules, which are based on the foregoing considerations are presented as a guide to designers when assigning tolerances. The tolerances recommended may be expressed either as plus or minus fractions or decimals of an inch or as a direct percentage allowance on the total dimension. Extra handling or finishing may be required to obtain tolerances closer than the normal specified in Rule 1. Except in rare instances, such operations will increase the manufacturing cost of molded hard rubber parts approximately as Rules 2 to 5 indicate.

1. For hard rubber molded parts, where requirements are such as not to warrant extra charges for accuracy, the drawing should allow a normal tolerance of not less than ±0.6 percent or ±0.012 in. whichever is greater, if the part is to be produced in a single cavity mold; and not less than ±0.75 percent or ±0.015 in. whichever is greater, if the part is to be produced in a multiple cavity mold, on all dimensions that do not cross the parting line of the mold. An additional +0.015 in. should be allowed on any dimension that crosses the parting line of the mold.
2. A tolerance of ±0.5 percent, but not less than ±0.010 in., whichever is greater, will increase the manufacturing cost 2 to 10 percent.
3. A tolerance of ±0.4 percent, but not less than ±0.008 in., whichever is greater, will increase the manufacturing cost 10 to 20 percent.
4. A tolerance of ±0.3 percent, but not less than ±0.006 in., whichever is greater, will increase the manufacturing cost from 20 to 50 percent.
5. A tolerance of ±0.2 percent, but not less than ±0.004 in., whichever is greater, will increase the manufacturing cost from 50 to 90 percent.

The minimum dimension D that would carry a tolerance expressed in percentage in all cases covered by the foregoing rules is 2 in. Thus

Rule 1. For single cavity molds

$$D = \frac{\pm 0.012 \times 100}{\pm 0.6} = 2 \text{ in.}$$

For multiple cavity molds

$$D = \frac{\pm 0.015 \times 100}{\pm 0.75} = 2 \text{ in.}$$

Rule 2. $$D = \frac{\pm 0.010 \times 100}{\pm 0.5} = 2 \text{ in.}$$

Rule 3. $$D = \frac{\pm 0.008 \times 100}{\pm 0.4} = 2 \text{ in.}$$

Rule 4. $$D = \frac{\pm 0.006 \times 100}{\pm 0.3} = 2 \text{ in.}$$

Rule 5. $$D = \frac{\pm 0.004 \times 100}{\pm 0.2} = 2 \text{ in.}$$

EXAMPLE: A part is to be molded of hard rubber, for which the tolerance requirements are such as not to warrant extra charges for accuracy of dimensions. (A) What should the tolerance be on a 1¼ in. dimension? (B) What should the tolerance be on a 12 in. dimension?

SOLUTION: (A) Since the nominal 1¼ in. dimension is less than 2 in., for single cavity molds this dimension with minimum tolerance should be $1\frac{1}{4} \pm 0.012 = 1.238$ to 1.262 in.

If across the parting line of the mold, the dimension should be

1.238 to (1.262 + 0.015)
= 1.238 to 1.277 in.

For multiple cavity molds, where it does not cross a parting line this dimension would be

$1\frac{1}{4} \pm 0.015 = 1.235$ to 1.265 in.

where it does cross a parting line this dimension would be

1.235 to (1.265 + 0.015)
= 1.235 to 1.280 in.

(B) For the 12 in. dimension, for single cavity molds this dimension with minimum tolerance should be

12 ± 0.6 percent of 12 = 12 ± 0.072
= 11.928 to 12.072 in.

If it crosses a parting line of the mold, this dimension with minimum tolerance should be

11.928 to (12.072 + 0.015)
= 11.928 to 12.087 in.

For multiple cavity molds, where it does not cross a parting line this dimension would be

12 ± 0.75 percent of 12 = 12 ± 0.090
= 11.910 to 12.090 in.

where it does cross a parting line this dimension would be

11.910 to (12.090 + 0.015)
= 11.910 to 12.105 in.

For the molded hard rubber part shown in Fig. 1 to hold the tolerances specified, the holes would have to be jig drilled and counterbored, and the end of the piece would have to be machine finished to hold the $11\frac{1}{4} \pm \frac{1}{64}$ in. dimension.

If it is assumed that this piece is to be molded in a single cavity mold, then if the tolerance was ±0.6 percent or ±0.012 in., whichever is greater, with $+\frac{1}{64}$ in. across the parting line, all holes could be molded and no finishing would be required on the end. The maximum variation to be expected on the 5.250 in. dimension would be ±0.6 percent of 5.250 or ±0.0315 in. As the holes are $\frac{9}{16}$ in. dia, ½ in. bolts would assemble without interference.

The greatest variation to be expected on the $11\frac{1}{4}$ in. dimension would be ±0.6 percent of $11\frac{1}{4}$ or ±0.0675 inch.

The greatest variation to be expected on the $10\frac{1}{4}$ in. dimension for location of the tapped holes would be ±0.6 percent of $10\frac{1}{4}$, or ±0.0615 inch.

The greatest variation on the 1.875 in. dimension would be ±0.012 inch.

The ¾ in. thickness will be affected by the parting line of the mold. The tolerance required on this dimension would be +0.027 in. and −0.012 inch.

If these variations would not interfere with the assembly or performance of the part, considerable savings in overall cost could be realized by specifying a tolerance of ±0.6 percent or ±0.012 in. whichever is greater, and $+\frac{1}{64}$ in. allowance for the parting line of the mold.

Designers can reduce cost of molded hard rubber parts by specifying maximum acceptable tolerances.

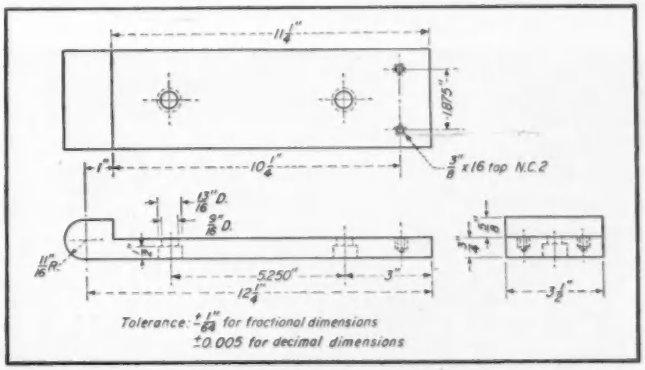


Fig. 1—Drawing of a molded hard rubber part that specifies tolerances which if held would increase manufacturing cost from 50 to 90 percent more than cost of the part if tolerances of ± 0.6 percent or ± 0.012 in. whichever is greater, and + 1/64 in. allowance for the parting line of the mold, would be acceptable.

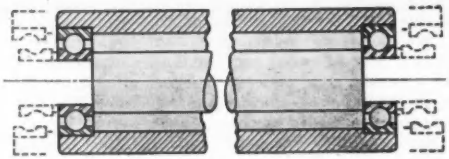


Fig. 1—Differential lineal expansion between shaft and its supporting housing when the temperature increase of the housing is greater than that of shaft.

BALL BEARING PILLOW BLOCKS

To Compensate for Shaft Expansion

RUSSELL E. DOWNS
Engineer, The Fafnir Bearing Company

IN MANY MACHINES, two ball bearings are spaced apart with their inner rings rigidly attached to a steel shaft and their outer rings mounted in housings that are part of or are rigidly attached to a cast iron or steel supporting structure. In such designs, since the lineal expansion of cast iron and the common steels are approximately the same, when the whole assembly simultaneously undergoes an equal temperature change, all parts expand or contract at the same rate. Under these conditions, no relative lateral displacement occurs between the inner and outer rings of either bearing.

When the temperature change of the shaft is different than that of the supporting structure, however, one member will lengthen or shorten more than the other as is indicated in Fig. 1. If provision is not made to accommodate this difference in length both bearings will be heavily loaded by an axial thrust.

While "non-expansion", "non-floating" or "held" ball bearing units, Fig. 2, are essentially fixed mountings, they do have the ability to accommodate a limited amount of differential lateral movement between the shaft and housing supports. This axial flexibility is made up of internal lateral play of the ball bearing itself, some slight lateral play between bearing outer ring and its housing seat, lateral deflection or spring of the bearing internally, and lateral deflection of the bearing in its housing under nominal thrust loads.

The amount of available float in "fixed" ball bearing units varies with the size of the unit, and also with the particular speed and magnitude of load. For two units the float is about double the inherent lateral play of a single bearing. As a rough-and-ready guide, the float may be considered as 0.010 in. for shaft sizes up to 1 in.

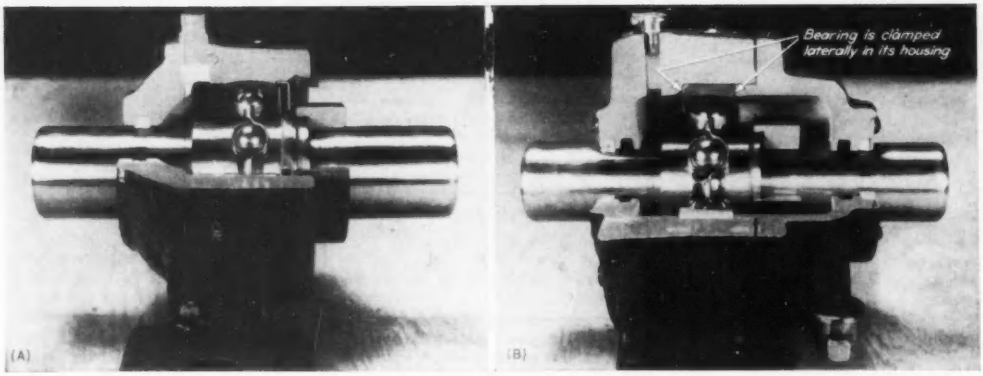


Fig. 2—Fixed or non-expansion type ball bearing pillow blocks. (A) Grease lubricated bearing. (B) Oil lubricated bearing.

dia, plus 0.005 in. per additional inch of shaft diameter. Where greater relative expansion must be accommodated, a combination of fixed and floating expansion type blocks is indicated.

The floating unit, Fig. 3 (A), of a fixed-and-floating pair, Fig. 3 (B), of ball bearing blocks is so designed that the bearing is free to move laterally in its housing. It can accordingly accommodate relatively large amounts of differential lineal expansion between the shaft to which the bearing is rigidly attached and any support to which the housing is fastened.

Where temperature conditions cause a difference in the thermal expansion of the associated parts of a machine or an assembly, the designer's choice of type of ball bearing housed units is generally limited to one of three types:

1. Standard grease-lubricated fixed units.
2. Fixed-and-floating pairs.
3. Fixed-and-floating units provided with special cooling arrangements.

Standard grease-lubricated fixed types are suitable under normal temperature conditions. Their seals are not intended to retain oil or melted grease, therefore, these units are not recommended for temperatures exceeding 175 F. No provision is made in these units to permit one bearing to float, hence, the machine design must be such that lengthwise thermal expansion of the shaft between bearings is approximately equal to the expansion of the parts on which the bearings are mounted; otherwise thrust loading of the bearings will result.

Fixed-and floating oil lubricated pairs are designed for an oil temperature limit of approximately 275 F within the bearing housing, above which temperature most petroleum base lubricants break down. While usually designed for oil lubrication, these units can be altered to employ grease by replacing the oil cups and fittings with grease cups and fittings. In addition to providing for lateral "float" in one of the units, the bearings are fitted with sufficient internal clearance to allow for a considerable thermal expansion differential between the inner and outer ring and ball complement. To avoid pinching if the bearing should expand radially, they are also freely fitted into the housing.

Fixed-and-floating, oil lubricated unit constructions with auxiliary cooling arrangements, Fig. 4, are designed for applications where large amounts of heat are present. Temperature limit of operation is approximately 275 F oil temperature within the bearing housing. Watercooling is commonly employed. It is effective where the heat transfer to the bearing unit is through the shaft, and also where the unit is completely enclosed in a heated atmosphere as in an oven.

Cooling fins cast integral with the housing provide a moderate degree of heat dissipation but their effectiveness, of course, is restricted to applications where the surrounding atmosphere is relatively cool.

Circulating oil lubrication and cooling offers an effective means of suppressing housing temperatures and provides excellent bearing lubrication as well. It is expensive because of the extra oil handling equipment needed.

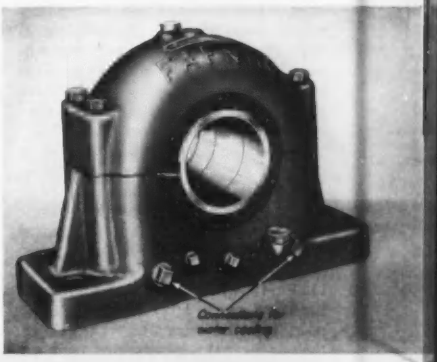
When abnormally high temperatures are encountered, special means may be necessary for dissipating excessive shaft heat before it reaches the block. Otherwise in spite of efficient cooling of the block itself, localized hot spots might exist within the unit, at the seal, on the shaft, or at the bearing inner ring. Cooling disks or small sectioned paddle wheels, clamped to the exposed section of the shaft between the heat source and the pillow block, are commonly used where surrounding temperatures are normal. High ambient temperatures may necessitate the use of a water box at this section of the shaft, or of an air or water cooled hollow shaft.

Special bearing steels and special lubricants are available for extreme conditions where the temperature of the bearing unit cannot be kept below 275 F., but their use may result in some sacrifice in normal bearing life or load capacity.

Many types of industrial equipment require a consideration of thermal expansion in the selection of pillow blocks. Numerous such problems are found in the installations of centrifugal fans. The standard belt drive overhung wheel and the standard overhung pulley arrangements present all the expansion problems associated with any of the others.

FAN OVERHANGS BEARINGS. In the overhung wheel arrangement shown in Figs. 5 (A) and (B), the fan wheel

Fig. 4—Pillow block with oil or water passages in its base to provide cooling of its section that is in contact with the bearing ring elements and the oil reservoir.



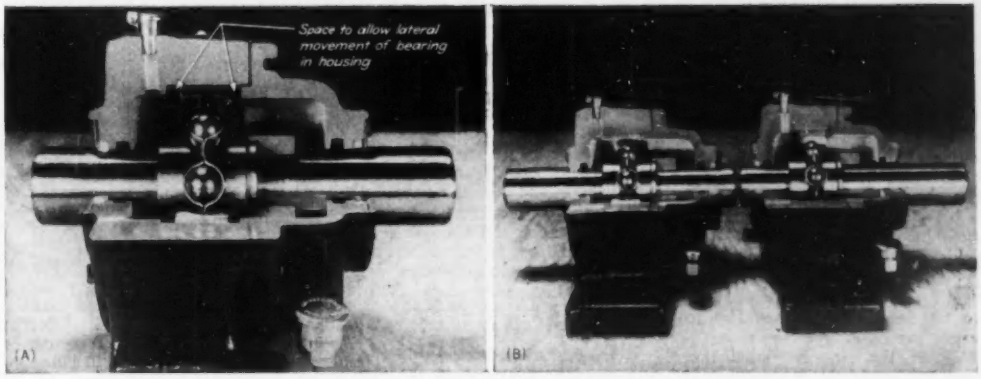


Fig. 3—(A) Floating or expansion type pillow block, oil lubricated. (B) Fixed-and-floating pair of oil lubricated pillow blocks.

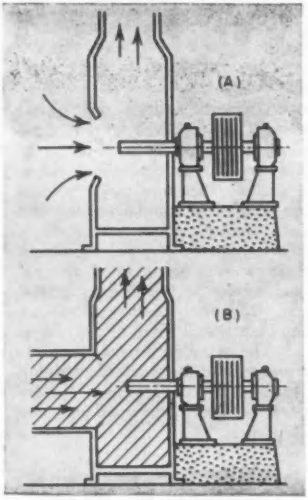


Fig. 5—Centrifugal Fan. Wheel and housing overhang the shaft bearings. (A) Housing with open inlet. (B) Inlet of housing connected to a duct.

and housing overhang the shaft bearings. The bearings are two pillow blocks mounted on a common pedestal support. The pulley may be either outboard to or between the blocks. This type of mounting seldom requires more than the limited inherent float provided by non-expansion or fixed blocks.

When the inlet to the housing is open to the surrounding atmosphere, Fig. 5(A), or when the fan housing is part of the closed system, Fig. 5(B), that is handling air or gas at the same temperature as that surrounding the housing, all parts of the fan and its mounting will expand or contract at the same rate. Hence, there will be no differential expansion regardless of the air or gas temperatures, and no provision for float is necessary.

When the fan housing is part of a closed system, Fig. 5(B), and the gas or air being moved is at a substantially different temperature than that surrounding the fan housing, some differential expansion occurs between the section of shaft between bearings and the section of pedestal or other support between blocks. But since this portion of the shaft and the bearing supports are in a common surrounding temperature, and since in this type of fan mounting the spacing between bearings is relatively short, this differential expansion between the two members is seldom sufficient to warrant expansion type blocks.

Assume that in the installation shown in Fig. 5(B), the temperature of the gas within the housing is 600 F, the ambient temperature around the housing is 80 F (housing and ducts insulated), spacing between bearings 24 in., and the shaft diameter is 2¼ in. The heat conducted along the shaft and along the pillow block support might, as an extreme, establish a temperature differential of 50 deg F between these members. If so, the differential expansion that must be accommodated would be

$$0.000006 \times 24 \times 50 = 0.007 \text{ in.}$$

which is well within the axial flexibility of a pair of typical 2¼ in. non-expansion type ball bearing units, the limitations of which according to the rule previously given would be

$$0.010 + 0.005\ (2\tfrac{1}{4} - 1) = 0.017 \text{ in.}$$

FAN BETWEEN BEARINGS. In the overhung pulley arrangement shown in Figs. 6(A) and (B), the fan wheel and housing are between the shaft bearings. When the air or gas being handled is the same temperature as that surrounding the housing, all associated parts of the mounting assume a like temperature. Hence, no differential expansion occurs between the shaft and the pillow block supports.

When the fan is part of a closed system handling gas or air at a temperature substantially different than that surrounding the fan, the relative expansion of the shaft and pillow block support must be considered in the selection of a proper block.

Normal speed fans of this type, designed for cold or moderately high temperatures, generally have the pillow blocks mounted on angle iron brackets attached to the fan housing as shown in Fig. 6(A). The housing then is the pillow block supporting member and expands and contracts with temperature changes in the housing. The housing, however, assumes a temperature slightly different than that of the shaft within it, as a result of radiation and other heat losses even though the housing is insulated. This temperature differential together with the relatively long shafts and wide housings required in this construction may result in an appreciable difference in the thermal expansions of the two members.

Assume that this fan application handles hot air at 600 F, room temperature is 80 F, and the shaft size is 2¼ in. as in the previous overhung wheel example. Assume also that the shaft between bearings is 54 in. long and the extreme housing temperature is 50 deg cooler than that of the shaft. Then the differential expansion between the two members would be

$$0.000006 \times 54 \times 50 = 0.016 \text{ in.}$$

or at the float limit for 2¼ in. non-expansion blocks.

When either operating speed or housing temperature is exceptionally high, fans with overhung pulleys usually have the pillow blocks as shown in Fig. 6(B) mounted on separate rigid pedestals attached to the floor or other support, but not to the fan housing. Depending on the temperatures, the housing is insulated more or less from the surrounding atmosphere and from its support. Any heat within the housing, therefore, causes little or no temperature rise in the structure supporting the blocks.

In such a fan application, the differential expansion between the shaft and the pillow block mountings may be considerable and, accordingly, expansion type blocks may be required. To illustrate, assume that the fan with blocks mounted on individual pedestals, Fig. 6(B), operates under the same conditions as the previous fan example. The differential thermal expansion between shaft and pillow block supports would then be

$$0.000006 \times 54\ (600 - 80) = 0.168 \text{ in.}$$

which is far beyond the limit of float of 2¼ in. non-expansion blocks. This application, therefore, would definitely call for a floating type mounting.

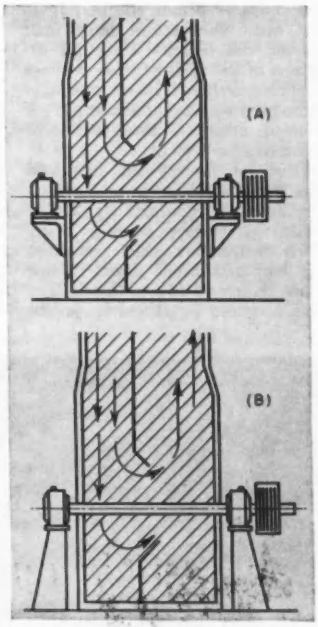


Fig. 6—Centrifugal Fan. Wheel and housing are mounted between shaft bearings. Pulley overhangs bearings. (A) Pillow blocks are supported on angle iron brackets attached to housing. (B) Pillow blocks are mounted on rigid pedestals not attached to housing.

TEXTURED Organic Coatings

New one- and two-coat spray application "special effect" finishes are rapidly supplanting older types. Application characteristics, appearance and film properties compare favorably with the usual protective enamels.

LESTER BACK

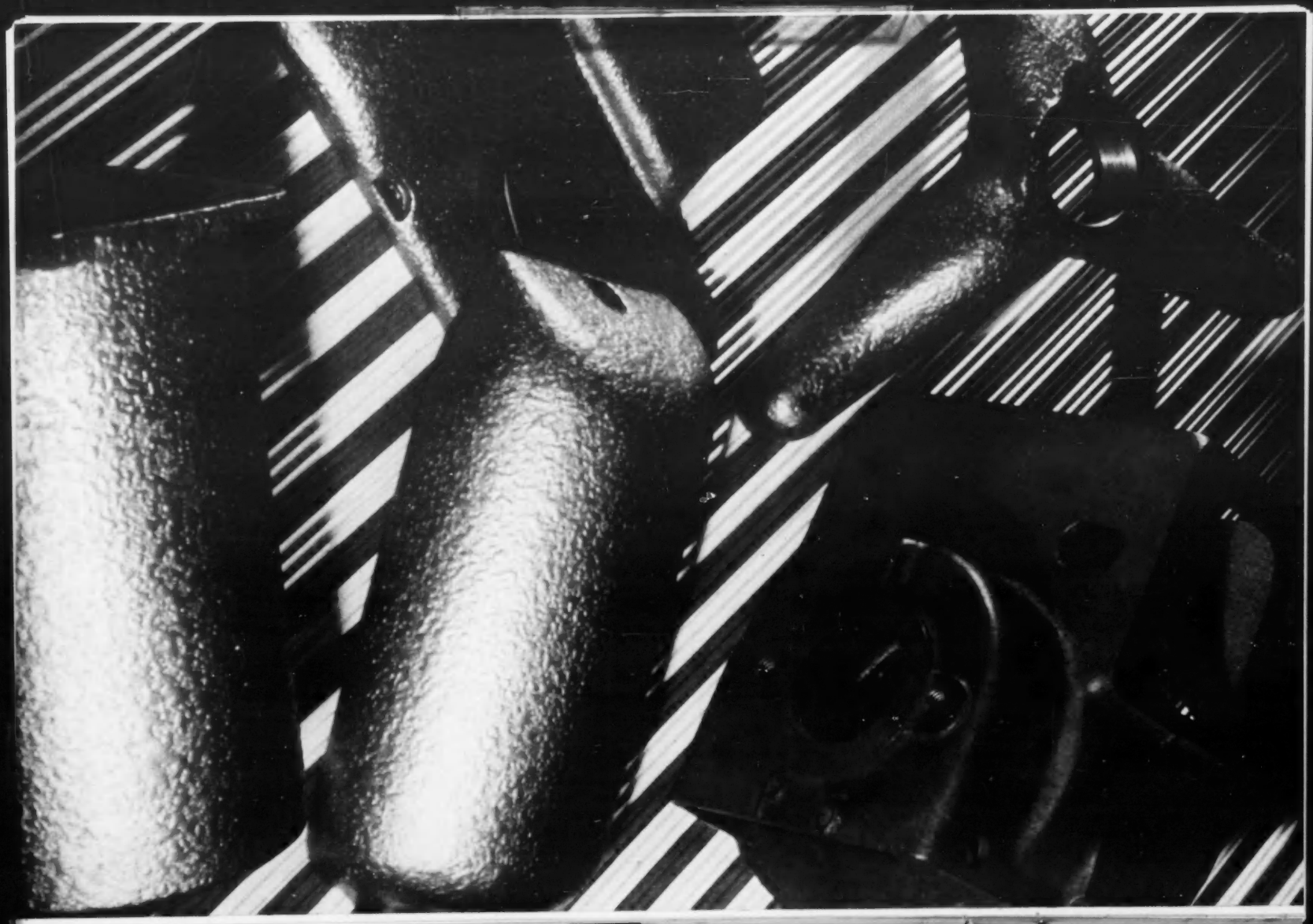
The Sherwin-Williams Company

Textured organic finishes serve the double purpose of protecting metals and furnishing coatings of unusual eye-appeal. In contrast to ordinary organic enamels which exhibit a smooth unchanging surface, all textured finishes have some form of variegated surface. They are especially useful on industrial products having broad plane surfaces, which would have reduced sales appeal with monotonous finishes.

These finishes also serve the important purpose of disguising metallic defects. Often production and finishing operations, such as spot-welding and sanding, leave marks on a metallic surface which are difficult to cover with one coat of ordinary paint. Textured finishes, because of their unique optical effects, obscure such surface defects effectively with one coat.

Effects obtained with these finishes are derived from the paint itself—no special preparation of the surface is necessary. Over steel the only treatment needed is cleaning. Over cast iron, aluminum, zinc, plastics, and other types of surfaces the preparation is the same as for spraying with ordinary organic enamels.

Spraying is the most advantageous method of application for obtaining these effects. Wrinkle finish can be brushed or dipped, crystal finishes are sometimes applied by brush, but spraying is still the best method. All other textured finishes must be applied by spray, because brushing or



dipping disturbs the conditions necessary to produce a pattern. Dipping or brushing cannot be used in systems where two materials are necessary to obtain an effect.

Polychrome Metallic

The polychrome metallic finish, sometimes called opalescent or metallic finish, contains aluminum pigment along with the color pigments, giving it a singular optical effect. Light reflects from the particles of aluminum and gives a scintillating appearance. This iridescence has been used to advantage in the finishing of automobiles, since bright sunlight brings out its beauty. In addition, this finish possesses a quality known as "flop", in which the color changes as the angle of view to the surface is changed, thus breaking any monotonous effect.

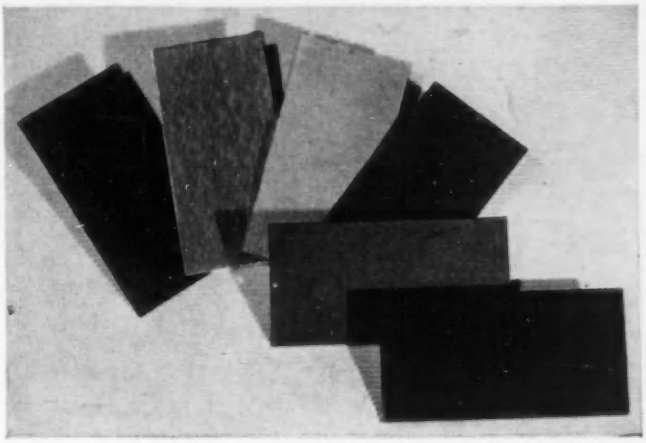
The spraying of an opalescent finish requires no special equipment—the same gun and equipment are used as in normal enamel spraying. Several factors are necessary, however, to produce an attractive effect. The viscosity must be sufficiently low—too high a spray viscosity produces small "hammers" which detract from the beauty of the finish. These small "hammers" tend to agglomerate the aluminum particles and prevent them from being uniformly distributed throughout the film; thus the effect obtained by light striking the individual aluminum particles is nullified. The same condition is produced if the material is sprayed at too low a pressure.

There must be sufficient break-up in the spray fan so that the individual spray droplets are small enough to prevent forming "hammers". This atomization pressure will vary, depending on the formulation and viscosity of the material.

Best spray results are obtained when a full wet coat is applied first and then a second coat lightly misted over the full coat. The mist coat can be applied immediately; it is not necessary for the wet coat to set.

Polychrome metallic finishes come in both lacquer and synthetic types. The lacquer type can be baked or air dried; the film must be thoroughly dry before it is polished or rubbed. The synthetic type is usually baked, but it can also be formulated as an air dry material.

Baking schedules vary, depending on the particular vehicles used. The majority of formulations fit baking schedules equivalent to 20-30 min at 300 F, to obtain optimum film properties. Since there is a choice of vehicles, a variety of finishes can be formulated, all differing in quality. Thus, price can be balanced against factors like hardness, gloss, adhesion and other film properties.



The Egyptian Lacquer Manufacturing Co. (flock panel) and the Sherwin-Williams Co.

Special effect finishes (left to right): Black wrinkle; one coat hammer; "Dimenso" hammer (two fluid system); opalescent (polychrome metallic); wrinkle; and "Flock" finish applied over synthetic resin baking enamel.

Cast iron oil burner parts are coated with "pebble" finish, which is an air-drying high viscosity spatter type, sprayed on with a special spatter gun. The rough iron castings are first treated with a pigmented lacquer-type (organic) primer, shown at upper right, and then finished with the green spatter coat, which is highly resistant to heat and moisture.

Maas and Waldstein Company

Hammer Finishes

Hammer finishes are basically the same as polychrome metallic, but instad of being a smooth film optically, the surface appears to possess many small indentations resembling hammer blows. There are several ways in which this effect can be obtained.

TWO COAT HAMMER. This is a metallic which has been "misted" with a fine coat of solvent. Small droplets of solvent falling on the wet coat of metallic produce the hammer effect. This system has been replaced to a large extent by other methods of producing a hammer finish, but it does have some advantages. Deep and dark colors and colors containing white pigments can be made up in the two coat system, while these colors inhibit pattern formation in the other systems. In the two coat hammer the greatest contrast is derived in the deep colors because the aluminum "floods up" in each little hammer and offers a striking contrast to the background color.

Several disadvantages of two coat hammer, however, have been responsible for its replacement by the other system. Uniformity of pattern spacing is likely to be poor unless the sprayman has excellent spray technique. Another disadvantage is the necessity for two spray setups to perform the job.

Spray technique consists of applying one full coat of the metallic ground coat with a conventional spraygun. This is then lightly and very quickly misted with solvent using a special spatter gun. The atomization pressure on the spatter gun is very low, allowing the solvent to be ejected from the gun in droplets. The size of these droplets will of course determine the size of the hammer pattern.

Baking schedules for these finishes are the same as for the poly-

FINISH	SURFACE TYPE	SUGGESTED USES	APPLICATION	AIR DRY AND BAKING SCHEDULE	CHEMICAL COMPOSITION
Metallic	Smooth Metal	Automobile Finishes, plus items below	Ordinary spray equipment	20-30 min* at 300 F	Alkyd or Lacquer
Two coat hammer	Smooth Metal	Furnace jackets Cash registers Business equipment	2 spray setups necessary	20-30 min* at 300 F	Alkyd
One coat hammer	Smooth Metal	Electric Fans Oil burners Auto heaters	Ordinary equipment	Air dry to touch 10 min. Bake may vary from 5 min at 300 F to 45 min at 240 F	Alkyd
Two fluid single application hammer	Smooth Metal	Vacuum cleaners Vending machines Tool boxes	Special spray gun	15 min at 325 F	Alkyd
Wrinkle	Smooth Metal or rough casting	Metal novelties Caskets Electric fans	Ordinary equipment	1 hr at 225 F to 15 min at 325 F depending on color; or air dry	Alkyd or oleoresinous
Spatter	Smooth Metal	Laboratory equipment Air conditioning equipment Fishing tackle boxes	2 spray setups necessary	20-30 min* at 300 F	Alkyd
Crackle	Smooth Surface	Novelty finishing	2 spray setups necessary	Lacquer drying	Lacquer
Webbing Lacquer	Smooth Surface	Novelty finishing	1 and 2 spray setups	Lacquer drying	Lacquer
Crystal finish	Smooth Surface	Novelty finishing	Ordinary equipment	Air dry 1 hr	Lacquer
Flock finish	Any type — steel, wood, cloth, etc.	Instrument case interiors Lamp and telephone bases Soundproofing surfaces	2 spray setups	Air dry 4 hr	Alkyd and fiber

*Can be varied depending on formulation

chrome metallic, since both are basically the same material. The film properties are also similar.

Two coat hammer can be used on a variety of products but it is usually recommended for use where a color cannot be obtained in the other hammer finishes. It is also used where the designer desires a contrast between the individual hammers and the color coat.

ONE COAT HAMMER. This finish has been rapidly gaining in popularity and very often replacing other specialty finishes for product finishing. There are several reasons for such replacement: Application is quite simple and no special equipment is necessary. The same type of gun is used as in spraying regular enamels and any sprayman can learn to apply this finish in a short time. The baking schedule can be very short allowing stepped up production. In addition, this material has a high gloss, thus accentuating the hammer effect by giving it a pronounced depth.

One coat hammer is usually supplied ready to spray at a viscosity of about 60 seconds on the No. 4 Ford viscosity cup at 75 F. Viscosity is a very important factor in this type finish as it has a direct bearing on pattern size and the type of pattern produced. High viscosity gives a large pattern, whereas low viscosity produces a small pattern. However, there is a definite working viscosity range and attempts to spray outside this range result in poor work. Excessively low viscosities tend to nullify the hammer effect, producing an opalescent type of finish instead of a hammer; too high a viscosity does not allow the material to be atomized and a continuous film cannot be produced.

In addition to viscosity, atomization pressure is also a critical factor in pattern size. This means that the atomization pressure must be closely controlled to produce a desired pattern. Pattern is also controlled to some extent by the tank pressure; the higher this pressure the larger will be the pattern and the greater the amount of material deposited. The tank and atomization pressures have to be balanced to get the best results—for most applications this will be in the range of 10-20 psi tank pressure and 40-60 psi atomization pressure. The figures can vary depending on the type of pattern desired, rate of production, and the pressure drop occurring in the lines. These two variables, viscosity and atomization pressure, are most important in maintaining day-to-day uniformity.

The hammer pattern itself can vary from an effect resembling peen hammer blows on metal to that of

IN A WIDE VARIETY OF APPLICATIONS

HARDNESS	MAR RESISTANCE	GLOSS	COLOR POSSIBILITIES	HEAT RESISTANCE	INTERIOR OR EXTERIOR EXPOSURE	EASE OF CLEANING
Good*	Good*	High*	Colors containing white pigment not recommended	Good*	Interior or exterior	Good
Good*	Good*	High*	Any range of colors except white	Good*	Interior	Good
Good*	Good*	Very high	Very dark colors and colors containing white not recommended	Good to excellent*	Interior	Good
Good	Good	High	Very dark colors and colors containing white not recommended	Good to excellent*	Interior	Good
Good	Fair	High to low	Wide color range	Yellowing apparent in light colors	Interior	Fair to difficult
Good*	Good	High*	Wide color range	Good*	Interior	Fair to difficult
Fair	Fair	High	Wide color range	Poor	Interior	Good to fair
Fair	Fair	High	Two-color system. Wide color range	Poor	Interior	Good to fair
Poor	Poor	High	Wide color range	Poor	Interior	Good to fair
Cloth	Cloth	Cloth	Any colors	Poor	Interior	Fair to difficult

a heavy coarse surface. Selection of a pattern type is purely subjective; some designers prefer the heavy wavy pattern while a majority show a preference for the effect resembling hammered metal. With correct viscosity and pressure settings, the most attractive and uniform pattern is obtained by spraying rapidly over the product to be finished. Both fluid and air feeds on the spray gun should be fully opened. While an ordinary spray gun is used, the air cap and nozzle should be of special size.

One coat hammers come in air dry and baking types, but baking types are much more important industrially. The air dry material dries to touch in ten minutes and can be handled after an overnight drying period. Baking types require a short bake; schedules as short as 5 minutes at 300 F are sufficient to give a good tough film. Extending this baking time will of course produce a harder and tougher finish. Corresponding baking schedules for infrared baking may be used to advantage. Adhesion of the baked film is excellent and the hardness measures 5H on the pencil test. The gloss is higher than any other of the other textured finishes approaching 90 deg on a 60 deg glossmeter. Water and mild alkali resistance are good.

Color possibilities extend over a fairly wide range but there are some limitations. Colors which contain a large amount of white pigment cannot be duplicated in one coat hammer, since the opacity of the white pigment tends to hide the hammer effect; the higher the pigmentation the more obscure will be the pattern. Dark colors also present the same problem. If a hammer finish is desired in a dark color or a color needing white pigment, the two coat hammer system is recommended. The best one coat hammer patterns are derived from the lighter colors. In fact, light tints accentuate the hammer pattern (see illustrations).

One coat hammer finishes are applied in the heating industry, as an excellent coating for furnaces, space heaters and stokers, because of its beauty of finish and its good heat resistance. It is also used on automobile heaters, vacuum cleaners, coin machines and motors.

TWO FLUID SINGLE APPLICATION SYSTEM. Another method of obtaining a hammer pattern is to pipe two materials to a special gun and eject it as a single spray. The product is known as "Dimenso". In this system there is a light viscosity material known as the "background" and a heavy material known as the "accent". As both

of these materials leave the spray gun the accent separates from the background, spatters on the surface being finished, and forms the hammer pattern. The pattern obtained in both this system and the one coat hammer are similar in appearance, but the two fluid system is characterized by a greater degree of pattern uniformity.

This system, however, offers color effects which cannot be produced by the other methods of making a hammer finish. In the one coat and two coat hammer finishes the color is solid—the only contrast is the "flooding up" of the aluminum within the hammers. By using the new method, it is possible to have the background material one color and the accent another color. There is some intermixing of these components within the spray fan, but the contrast between accent and background still remains.

Uniform properties and quality are characteristic of this type of hammer finish. Both background and accent materials are kept closely to an established viscosity, thereby regulating the rate at which these materials are ejected from the spray gun. To further assist in this control small orifices are built into the special spray gun; these serve as metering devices to proportion the flow of the fluids.

Spray technique is similar to spraying one coat hammer: A single pass is made over the surface and the following pass slightly overlaps the previous one. Pattern size control is the same as with one coat hammer—important variables are viscosity, atomization pressure and tank pressure. Best results are obtained using 20 psi tank pressure and 40 psi atomization. These pressures can be varied to change pattern size.

Baking schedules are 30 minutes at 300 F, 15 minutes at 325 F, or their equivalent for infrared baking. The baked film is hard and tough, and gets progressively tougher after it has been baked. Its uniformity of pattern is excellent.

This finish is suitable for use on products such as furnace jackets, cash registers, vacuum cleaners, electric fans and laboratory equipment. The wide variation in effects possible, and the fact that only one application is necessary, make it extremely versatile.

Wrinkle Finish

Many varnishes exhibit the phenomenon of wrinkling under certain conditions and this is looked on as a defect in the development of a smooth film. However, this would-be disadvantage has been put to good use by selecting proper vehicles and additives to produce the attractive wrinkle finish.

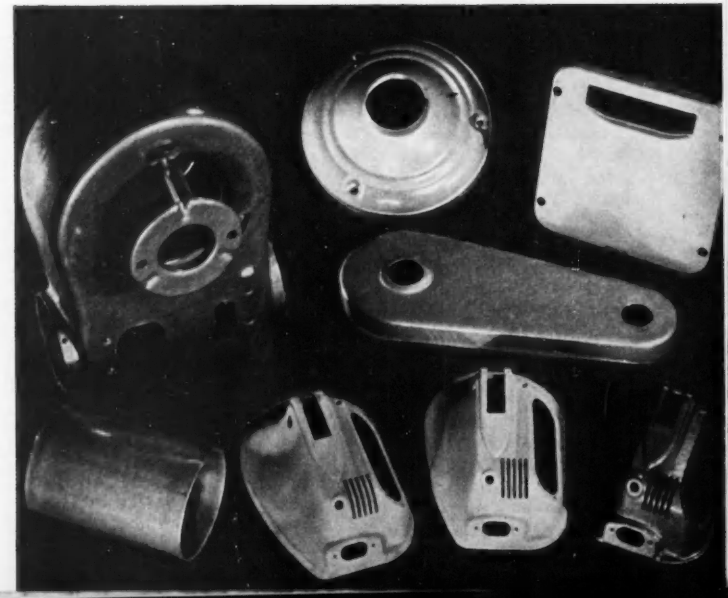
Wrinkle is applied with regular spray equipment. Air pressures of 60–80 psi in the gun and 5–10 psi in the fluid tank give the best results. In spraying it is of great importance that the correct film thickness be applied. Too heavy a coat produces "fish eyes" (spots on the finished surface which have a higher gloss than the wrinkle proper) and sags, and wastes material; too light a coat produces a film that does not wrinkle uniformly and may bake out with little wrinkle. For best results use a wet film thickness of about 4 mils.

Baking schedules necessary to wrinkle and harden wrinkle finishes vary somewhat, depending on the color of the finish. Lighter colors require a longer schedule, such as one hour at 225 F, or 180-225 F infrared. The medium dark colors can be baked at this schedule also, but if a short baking time is desired, 275 F for 20-30 minutes is satisfactory. Black wrinkles allow schedules as short as 15-20 minutes at 300-325 F. However, when baking temperatures higher than 275 F are used, the oven should be reduced to 250-275 F before it is recharged with newly sprayed pieces, since the wrinkle may not form at higher temperatures.

Uses for wrinkle finish include a vast number of products—such as tool boxes, business machines, furnace jackets, electrical appliances and auto radios. Business machines are finished in wrinkle because of its low gloss and nonglare features, minimizing eye fatigue. Users of delicate instruments find wrinkle's "gripping" surface an advantage.

An interesting form of wrinkle is the "pine tree wrinkle". This unusual effect is obtained by spraying a heavy coat of wrinkling varnish and baking for 35 minutes at 200 to 340 F, fifteen minutes of this schedule being at 340 F. Small nuclei form within the film and the wrinkle spreads out from these points to give an effect resembling pine trees. After the finished article is removed from the oven it

Textured finishes applied to sheet metal and die cast parts: Die cast aluminum oil burner part finished with baking-type "Dimenso" hammer; two sheet steel parts with one coat hammer; belt guard with baking-type "Dimenso" hammer; steel tube with one coat hammer; two aluminum die castings with wrinkle and one with air-dry "Dimenso" hammer. The Sherwin-Williams Company



is sprayed with bronze lacquer to highlight the "pine trees". Careful spray technique is required.

Spatter Finishes

Spatter finishes are produced by applying one paint film, and then "spattering" a second contrasting coat over the first coat. There are two principal methods of obtaining this type of finish—the two gun spatter system and the two liquids single gun method. However, they are somewhat different in appearance: In the two gun system the spatter spots are clearly defined from the first coat, in the other system the background coat and spatter intermix, producing a somewhat blended pattern.

In the two gun spatter system one spray setup produces the first coat and another setup including a spatter gun applies the "spots". This is a definite disadvantage, since finishing time is considerably increased.

The single gun dual liquid feed system is the same setup as that for producing "Dimenso" hammer finishes. The setup of special gun and equipment is the same; the only difference is that nonmetallic type paints are used. Tank and atomization pressures and viscosities are the same. These variables must be closely controlled however, to reproduce color and pattern. Since the heavy accent component is a different color from the lighter body background material, any change in the spraying ratio of these materials produces a slightly different color. The advantage of this system is that only one gun and one operation are necessary. Also, the effect obtained is distinctive and unique.

Another interesting spatter finish is known as "pebble" finish. The method for obtaining this effect is the same as used for the regular two coat spatter, except that the spatter coat is of very high viscosity. A special spatter gun is necessary to spray this high viscosity material.

Spatter finishes can be formulated in any type or quality, to match other industrial enamels. No special tricks or special vehicles are necessary to obtain the spatter effect; the only necessary condition is the method of spray. Baking schedules and film properties produced are similar to those of regular enamel finishes.

Lacquer Finishes

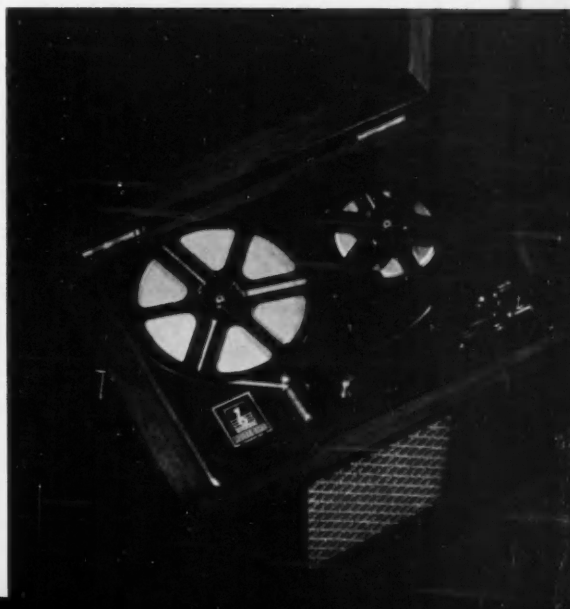
CRACKLE LACQUERS. These are produced by spraying a hard quick-drying lacquer over a slower drying flexible lacquer. Application consists of first applying a colored undercoat and allowing this to dry thoroughly. The crackle coat is then sprayed over the undercoat at a pressure of 40 psi. As the fast drying solvents evaporate, the top coat splits up and reveals the undercoat in an intricate pattern of irregular lines. Light coats of lacquer produce fine cracks, while heavy coats produce a large pattern. Many color combinations can be used in this system. Red lacquer and a black undercoat are commonly used. Other good combinations are green over black, dark blue over light blue, and gold, brown, or red over ivory.

WEBBING LACQUERS. Webbing or veiling lacquers are produced by spraying a rubber-like solution from a spray gun in strings which loop and criss-cross on the surface, to form many patterns in color. The high molecular weight material used contains a very volatile solvent such as acetone and the material forms a solid as it is sprayed from the gun. These solids form strings and result in a pattern as they strike the product.

CRYSTAL FINISH. This is an unusual and beautiful finish, obtained by blending lacquers with naptha-

Wrinkle finish is applied over die cast aluminum base of vacuum cleaner. This gives a hard, tough protective coating which is also attractive enough to enhance the sales appeal of the product. Color and type of wrinkle depend upon the baking cycle. The Hoover Company

Steel parts of the "Soundmirror", a home tape recorder, are finished with a "Dimenso" (two fluid) single application system. However, these parts are given a phosphate-type (inorganic) treatment before the textured organic coating is applied. The Brush Development Company



ORGANIC FINISHES FOR MI

	Oleoresinous Base Coatings	Bituminous Coatings	LACQUERS		Com
			Cellulosic	Other Types	Phenolic	
DESCRIPTION	Composed of drying oils — such as linseed, tung, castor, soya — plus synthetic and/or natural resins in chemical combination effected by processing (cooking). Normally available as solutions in aliphatic and/or aromatic hydro-carbons. Can be applied clear or pigmented as required. Addition of metallic driers necessary for air drying.	This classification includes: (1) Japans — natural asphalt with drying oils dissolved in petroleum solvents; (2) asphalt varnish — similar to Japan but made with petroleum asphalt; (3) bituminous enamels — high melting point asphalt or coal tar containing mineral fillers such as clay or asbestos.	Composed of nitrocellulose or other cellulosic resins — ethyl cellulose, cellulose acetate and acetate butyrate — plasticizers and pigments dissolved in volatile organic solvents. Coating film is formed on evaporation of solvents. However, many so-called "lacquers" are combinations of such thermoplastic resins modified with alkyd or other oxidizing resins which provide special properties.	Same as cellulosic, but instead of cellulosic resins, other thermoplastics such as vinyls and acrylics, are used.	Pure and modified types.	Phenolic alcohol — cent deve of styrene reducing kyds to
METHOD OF APPLICATION AND TYPE OF DRYING	Readily applied by brush, spray, dip or roller, depending on type and size of object to be coated. Can be air dried or baked. Drying is considerably slower than lacquers, as final hardening results from oxidation and polymerization of oils rather than by solvent evaporation. Extreme hardness can be obtained by heat curing (about 20-30 min. from 275 to 350 F). Adequate baking and greater oil-resin ratio will improve outdoor weathering resistance.	Spray brush or dip. Japans can be air dried, but when baked at high temperatures (300 F or higher) hard, semitransparent finish is obtained. Bituminous enamels are usually brushed on hot, giving extremely heavy films.	Usually sprayed, but can be dipped, roller coated, or brushed. Heavy coatings, such as tank linings or coatings for protection against shipping and handling (vinyls and cellulose acetate butyrate) are usually applied by hot dipping. Lacquers are usually air dried, but force drying — applying heat at relatively low temperature — can also be used to speed up drying. In spray application, extreme care must be exercised to avoid "orange peeling" which can be removed from dry film only by rubbing. In avoiding this condition, viscosity and solids control are important, along with a well-developed spray technique.	Spray, dip or roller coat. Usually air dried but can be force-dried for better adhesion.	Brush, spray or dip. High baking temperature (300-350 F) gives fast production.	Brush, sp Addition quired fo quired fo crackle o
PROPERTIES	High solids content permits deposition of heavy films per coat. Color retention only fair under heat treatment. Films not resistant to strong organic solvents; chemical resistance fair. Suitable for indoor or outdoor exposure, but properties depend on "oil length" — ratio of oil to resin. Excellent anti-corrosive properties are obtained when heavily pigmented with zinc chromate, red lead, or zinc and aluminum powders (especially for ferrous metal protection).	Japans are hard finishes. Applied varnishes have excellent water resistance, especially when aluminum powder is added to them. Bituminous enamels give excellent corrosion and water resistance.	Suitable for indoor and when properly formulated also for outdoor conditions. Speed of drying is outstanding. Toughness and flexibility in a wide range of temperature conditions are excellent. Nitro-cellulose is inflammable, but ethyl cellulose, cellulose acetate and cellulose acetate butyrate have low inflammability and good heat resistance. Best adhesion to metals, and best water resistance is obtained with nitro-cellulose type lacquer. For a given film thickness, more coats of lacquer are required than varnish or synthetic base paints, but this is being partly overcome by new hot lacquering technique (see "trends").	Vinyl coatings have excellent resistance to outdoor conditions, especially to continuous water immersion. Can be sprayed on as a "strippable" coating which is used to protect metals in storage for indefinite periods of time. Acrylic coatings are light and heat stable, and are resistant to water and some chemicals.	Phenolic finishes are relatively fast drying, and have excellent durability, chemical and moisture resistance. Modified phenolics have excellent abrasion resistance.	Superior resinous- tention. bility, ha good ad grease water re
APPEARANCE	Amber color in clear varnish; depth of color depends on type of resin used. In clear varnish, color tends to yellow when exposed to high temperatures. In pigmented coatings, flat to glossy enamel-type surface is obtainable, depending on pigment vehicle ratio and degree of pigment dispersion.	Japans are transparent, amber-like films. Asphalt varnishes and bituminous enamels are black. Latter are very dense, since they are applied by melting.	Supplied in clear and pigmented coatings that range in gloss from high to dead flat. With proper choice of solvents, extremely smooth finishes can be obtained. Novelty finishes such as crackle, webbing and crystal can be produced by carefully controlled application techniques.	Usually used as clear finishes; acrylics can be colored.	Usually pigmented only in dark shades because of dark color of vehicle.	Gloss en range c type of cept for mention with alky effects (c of hamm finishes. plied to finishes tallic su extent.
MAIN USES AND TRENDS	Widely used because of low cost, for structural steel and relatively inexpensive products such as hardware. More versatile synthetic resin finishes described (right) are, however, becoming more widely used for heavy machinery as well as specialized applications.	Japans are used where inexpensive but hard finishes are required; one of the oldest types of protective coatings for metals — sewing machine heads typical application. Asphalt varnish and bituminous enamels are used to protect iron pipes, water mains, and interior of ships.	Unpigmented (transparent) nitro-cellulose lacquers most widely used. Pigmented metallic lacquers used as automotive finish, also widely used on aircraft because of their lightweight. The new trend in application is toward hot lacquering, by means of which the spray viscosity of lacquer is reduced by heat instead of thinner, thus permitting application of heavier films per spray coat. A normal two-coat operation can be completed with one coat of "hot lacquer." Cellulose acetate butyrate can be used as a hot dip where extremely heavy coatings are required — such as for flashlight batteries. Although expensive, lacquers heavily loaded with metallic powders, such as stainless steel powder, are effective one-coat-protection for small ferrous and nonferrous parts.	Hot dip and cold sprayed vinyl lacquers widely used for protection of metallic parts during fabrication, shipment, and storage. Vinyl coatings used in protection of tank car interiors, fuel and chemicals storage tanks, and the like. Acrylic coatings are available as a proprietary "one step" finish for small metallic parts such as die castings; applied by brush, dip or roller coat, with short bake; outstanding moisture and chemical resistance claimed for them.	Marine finishes, electrical insulation, food and chemical processing equipment, tank car linings, food handling equipment, and automotive primers and surfaces. New modified furfuryl alcohol resin base, air-drying coatings are commercially available. They are similar to phenolics in many properties, but are claimed to be tougher and harder than unmodified phenolics. Electrical properties are outstanding. Cured films are black and opaque. Cost is higher than phenolics.	Enamels kitchen cluding nals, por as auto Typical finish co (percent Dying Melamin Urea for
SURFACE PREPARATION AND UNDERCOAT NEEDED*	Rust, dirt and oil must be completely removed by such methods as sanding, buffing and solvent cleaning. Where corrosion resistance is important, a chromate or phosphate dip should be applied prior to painting steel. Chromic acid anodization for aluminum alloys and chrome pickled treatment for magnesium prior to primer application insures improved corrosion inhibition. For stringent conditions, zinc metallizing should be used before painting. For metallic parts subject to continuous outdoor exposure, a zinc dust paint applied as a prime coat is quite effective, especially for ferrous materials (where smooth, high-gloss surface is not required). For extremely severe conditions, and where appearance is also a factor, the combination of a zinc coat, and an aluminum paint as a finish coat, is often used.	Clean surface obtained by sanding or rubbing with steel wool. Must be oil free. Never applied over primer.	Solvent or vapor degreasing is usually necessary. For resistance to moisture and corrosive conditions, preliminary chromate or phosphate treatments are essential. Oil or grease must be completely removed. Appropriate zinc yellow primer should be used prior to application to magnesium or aluminum.	Cleaning or degreasing operation is essential before applying lacquers. Solvent wipe or vapor degreasing generally used.		Surface treatment alkyd-type finishes degreasing, rust r chromate-type pri can be coated wit types are most oft A typical finishin follows: 1. The casting is fi 2. If oil or grease used. One com solvents and ph

*Maximum adhesion and durability can only be obtained if the surface on which the coating is to be applied is free of all dirt and grease. In addition to cleanliness, a chemical treatment of the metal surface is often a necessity. For maximum resistance to outdoor exposure, alkali, moisture and other severe conditions, a specially formulated undercoat is required.

OR METAL PRODUCTS

SYNTHETIC RESIN BASE COATINGS

Composed of one or more synthetic resins — the vehicle — combined with pigments and drying oils. Petroleum or coal tar solvents are used as thinners.

	Alkyd	Urea and Melamine	Styrene	Silicones	Vinyls	Rubber and Related Materials
	Phenolic anhydride — polyhydric alcohol — oil combinations. A recent development is the addition of styrene as a modifier, thereby reducing the drying time of alkyds to almost lacquer speed.	Never used alone — usually in conjunction with alkyd resins. Urea and melamine thermosetting resins, having high color stability at elevated temperatures, usually available in solutions of 50% solids in mixtures of coal tar and petroleum derivatives.	"Styrenated" oils and alkyds.		Polyvinyl butyral, vinyl chloride, vinyl chloride acetate, and vinyl chloride-vinylidene chloride, dissolved in ketones and alcohols.	Natural, synthetic (styrene-butadiene copolymers), chlorinated rubber.
king gives	Brush, spray, dip or roller coat. Addition of metallic driers required for air drying. Baking required for special effects, such as crackle or wrinkle.	Spray or dip application usually recommended. Drying by baking only ranging between 225-325 F. Some forms containing catalysts may be cured by force drying from 125 to 140 F.	Spray, brush, dip or roller coat. Air dry and baking. Some types of oil-modified styrenated polyesters dry "tack-free" in 10-15 min.	Spray or dip — always baked. Baking schedule varies from 15 to 30 min., at temperatures from 350 to 425 F.	Spray, dip and brush. Dries by solvent evaporation but often force dried at 200 F for better adhesion.	Spray, dip, and brush.
ively llent sture nolics esist-	Superior to phenolics and oleoresinous-type finishes in gloss retention. Possess excellent durability, hardness, heat resistance; good adhesion, flexibility, oil and grease resistance. Alkali and water resistance fair.	Good hardness, chemical and abrasion resistance; excellent oil and grease resistance. Brittle when used alone; must be combined with alkyds for flexibility and adhesion. Melamines provide for wider compatibility with pigments and other resins rendering them somewhat more versatile. Melamines have outstanding resistance to electrical arcs, are especially stable to heat and light.	High gloss, good stability and color retention. Limited compatibility with other film-forming resins.	Outstanding heat resistance — far superior to conventional finish in this respect. Also has good hardness and resistance to weathering. However, silicone enamels not containing metals have poor abrasion resistance. Good wet insulation properties.	Flexible and tough. Resistant to oils, foodstuffs, and many chemicals. Adhesion only fair; improved by incorporating an alkyd resin.	Flexible, tough, and highly resistant to water, chemicals, and abrasion.
dark or of	Gloss enamels possible in wide range of colors. Almost every type of special effect finish (except for lacquer novelty finishes mentioned left) are obtained with alkyd. These include metallic effects (automotive), various type of hammer, wrinkle and spatter finishes. All of these can be applied to smooth metal. Wrinkle finishes hide imperfections in metallic surfaces to a very great extent.	Wide range of colors, including white. Good gloss retention in wide variety of conditions, even after prolonged exposure to excessive temperatures and light. This makes them especially adaptable to light colored baking finishes.	Wide range of colors. Excellent decorative effects.	Wide range of colors, including white, which are stable at high temperatures. Compatible with pigments providing finishes of high gloss, with purity of color and tint.	Supplied as clear, pigmented, and dyed coatings. One type of vinyl dispersion coating ("organosols") is used both as a decorative and protective finish.	Not used for decorative effects.
nsula- ecess- nings, and faces. lcohol atings They many to be nmod- roper- films ost is	Enamels for wide variety of kitchen and outdoor products, including refrigerators, traffic signals, porch furniture. Widely used as automotive and truck finish. Typical vehicle for an automotive finish contains the following resins (percent): Dying alkyd (Short oil).... 65 Melamine ..... 15 Urea formaldehyde 20	Finishes for refrigerators, automobiles, hospital equipment, stove parts, and kitchen appliances. Urea resins combined with alkyds, and titanium dioxide are used as a baking refrigerator enamel.	Decorative and protective coating for smooth metallic parts, where appearance is the main factor, such as metal cabinets. Enamel finishes that air-dry as quickly as lacquers can be made from oil modified styrene copolymer solutions. Baking type enamels are also produced from such solutions.	Finishes for refrigerators, gas heaters, and stoves. Modified silicone aluminum paint used on a wide variety of heating equipment. Widely applied to electrical equipment.	Coating based on vinyl resins, and containing lead chromate and basic zinc chromate is used as a wash primer on aluminum, galvanized iron, and steel. Baked alkyd finishes are applied over the vinyl primers. Chemical resistant coatings containing modified vinyl resins are being developed for finishing such products as refrigerators and washing machines. Vinyl "organosols," in which the resin is suspended in a non-solvent, have limited use as metallic coatings. A variation of the technique, in which a polishing operation is included, produces a coating suitable for outdoor metallic furniture.	Used for unusually severe conditions. Chlorinated rubber paints are used for tank linings, and interiors of chemical containers and air conditioning equipment. Chemical resistant paints and marine paints are often formulated with chlorinated rubber because of its compatibility with drying alkyds of long oil length.
					Pre-cleaning and degreasing absolutely necessary.	Removal of oils and greases from surface is essential.

Surface treatments for metals to be coated with phenolic or alkyd-type finishes usually include the following: Solvent vapor degreasing, rust removal, flush with water, dry, spray with zinc chromate-type primer, air dry or bake. Although rough castings can be coated with almost any type of finish, phenolic or alkyd types are most often used.

A typical finishing system for cast iron machine parts is as follows:

1. The casting is first sanded or shot blasted.
2. If oil or grease is present standard alkaline cleaners can be used. One commercial cleaning preparation contains both solvents and phosphoric acid.
3. Immediately after cleaning, a primer should be applied. Corrosion resistant primer, containing red lead or zinc chromate should be applied.
4. If casting is porous, a filler is sprayed on, then sanded, to smooth out surface roughness.
5. A synthetic resin lacquer is then applied as a base, to provide a smooth surface which will have minimum paint absorption.
6. The final coat of synthetic resin base paint is then applied by dipping, spraying, or brushing. Enamel can be air dried or baked (if it contains urea or melamine). Note: if wrinkle or other textured finish is to be applied, all steps except filler can be eliminated.

New Wrinkle, Inc.

Wrinkle finish is applied to a variety of metal castings and stampings.

lene and camphor crystals. As air drying progresses the crystal design grows in size and can vary from a small crystal pattern to a long needle-like structure. The type of pattern obtained depends on crystal balance—an excess of naphthalene produces small designs, while greater amounts of camphor produce the elongated patterns.

Several factors must be considered in spraying this material. Air pressure must be kept low—about 20 psi, so that a minimum of solvent is released during spraying. The solvent used is a slowly evaporating type and it is important not to allow it to evaporate too quickly. Drying and crystal growth should be complete after about an hour, but a harder film is obtained if the piece stands for a day.

Film properties of this material are quite poor, and it should only be used on products that do not receive excessive abrasion.

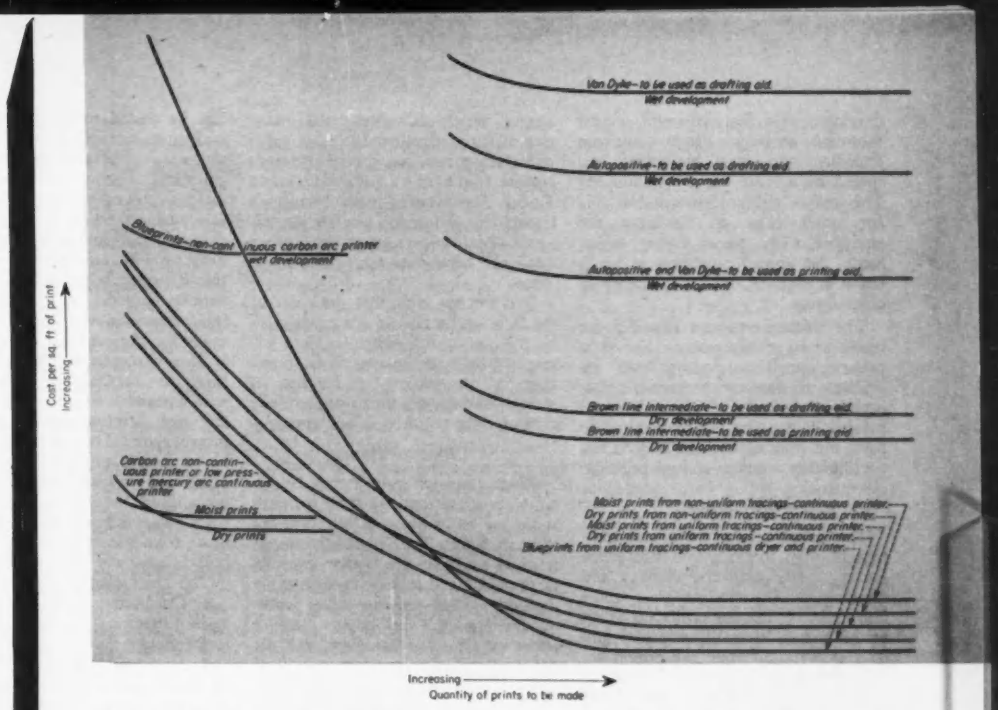
Flock Finishes

Flock finishes are not, by strict definition, textured organic finishes. However, they are useful supplements to the field of industrial finishes. They are prepared by first applying an adhesive (paint) and then spraying finely cut fibers onto the adhesive to produce a "pile" effect. Various types of fibers can be used: Cotton is used where a soft level surface is desired, and produces a soft suede finish. Rayon flock comes in longer fiber lengths, giving a longer nap which resembles velvet.

Flock adhesives include synthetic enamels, generally used on rigid surfaces such as metals, and synthetic resins and rubbers for flexible surfaces.

Application is accomplished with a special flock gun, although it is also possible to sift the fibers onto the adhesive, or to use an electrostatic method of application. In the gun method, the flock is usually sprayed at about 35 psi pressure. In spraying it is extremely important that no water enter the spray system.

Uses for flock finishes are varied. It finds considerable use as a lining for trunks, instrument boxes, automobile glove compartments, on the inside of any product where a soft plush effect is desired, and on other products that may be placed on easily marred surfaces. An important use is as a soundproofing agent in airplane interiors


Van Dyke—to be used as drafting aid
Wet development
Autopositive—to be used as drafting aid
Wet development
Blueprints—non-continuous carbon arc printer
Wet development
Autopositive and Van Dyke—to be used as printing aid
Wet development
Brown line intermediate—to be used as drafting aid
Dry development
Brown line intermediate—to be used as printing aid
Dry development
Carbon arc non-continuous printer or low pressure mercury arc continuous printer
Moist prints
Dry prints
Moist prints from non-uniform tracings—continuous printer
Dry prints from non-uniform tracings—continuous printer
Moist prints from uniform tracings—continuous printer
Dry prints from uniform tracings—continuous printer
Blueprints from uniform tracings—continuous dryer and printer
Cost per sq. ft of print
Increasing
Increasing
Quantity of prints to be made

Print-making costs must be considered. Floor space, storage room and ventilation facilities may limit choice. If prints are altered frequently or if tracings are handled a great deal, other factors enter.

Selecting Printmaking Equipment

GORDON MOODY
Essex Design Service
Essex, Conn.

Engineering drawings are printed by a variety of processes, each with advantages for some department or industry.

NO ONE PRINTMAKING PROCESS has a monopoly on good features and few engineering departments have printing needs that can be met by one process alone without some compromise with disadvantages in one form or another.

The considerations that enter into the selection include the (1) cost (2) adaptability to continuous or periodic production and (3) other factors such as fading, shrinkage, and storage. Developing equipment and developing machines are usually selected on the basis of cost and flexibility, while the type of print that is to be made may depend on other factors as well.

Practically all processes depend upon the use of light falling on some material coated with a light sensitive emulsion, but the methods of developing the image from the exposed emulsion may be divided into three classes.

CLASS I Processes requiring the complete wetting of the exposed material by solutions, followed by careful drying on special equipment, to produce a finished print free from wrinkles.

CLASS II Processes requiring swabbing of the exposed material with a developing solution to produce a print which is dried wrinkle-free in air without additional equipment.

CLASS III Processes using a moist vapor such as ammonia to develop the exposed material into a "dry print."

For small batches of small-sized prints, ordinary dark room equipment is adequate for wet development. For large quantities and big prints, continuous operating machines are perhaps a better solution.

For small intermittent work that is suitable for carbon arc printing, a semi-dry developing machine is ideal. These machines pass the paper over a roller rotating in a trough of developer. No warm-up or stopping time is required. A disadvantage lies in the fact that they gum up with evaporated

developer in a few days and require thorough washing. Prints come out semi-dry, and must be wiped and spread on a table for a few minutes. This makes the process suitable only for small runs on machines not equipped with special drying equipment. No special plumbing or ventilation is required, giving flexibility of office layout.

The ammonia process is suited for small or large equipment. For slow printers, small developing units are available to develop continuous prints rapidly, completely dry and undistorted by shrinkage. The heater required to bring out contrast in paper may be run continuously for stop-and-go printing.

Light Sources

The carbon arc has the great advantage of high intensity and immediate starting. Replacing the carbons and cleaning their protective glass globe is a nuisance, but for prints up to 24 by 36 inches, in small quantities and on a stop-and-go basis, the carbon arc is hard to beat.

Low pressure mercury arc tubes light instantly but lack great intensity. Printing speed is increased with two or three tubes in one machine and is satisfactory for moderate-quantity, continuous printing up to 44 inches in width.

High pressure mercury arc lamps are excellent for high production on continuous print machines. Slow starting and high heat dissipation mar their performance on certain types of work, however. Although they ignite instantly, full and steady brilliance is not attained for 5 to 10 minutes, and the attendant heat requires that the machine be run for a short period with the light off after each run to allow the tube to cool. Starting and stopping times make performance rather slow where short runs of a few prints are the rule.

The high brilliance of this light makes exposure of intermediate papers and cloth practical. It should be remembered, however, that these bulbs run hot and proper cooling of the glass cylinder carrying the prints is difficult. A hot glass cylinder will iron the wrinkles and roll out of tracing paper or cloth, but presents an almost insurmountable obstacle in printing foil. The light-sensitive emulsion on many foils requires long exposure, which heats the glass cylinder to the point where the film softens and breaks down into a series of washboard wrinkles that will not smooth out. Cooling the bulb with more air cuts brilliance and makes printing impossible.

All the above light sources produce strong violet and ultra-violet radiation. This is excellent for most paper and cloth prints, but special materials require light of a different color. Kodak Autopositive paper requires a transparent yellow foil filter, while certain Copyall papers must have green light and necessitate the use of paper filters.

It is felt by some that the color of the light source should not be changed by the use of the filters fed into the machine with the work. Such filters may be troublesome to handle. A special machine set up to produce the type of light required is one answer.

Types of Prints

Silver emulsion papers may be obtained in extra sensitive form for dark room use or in autopositive form for ordinary light. The autopositive paper is more sensitive than other intermediate papers and may be used to make duplicates from ordinary blue prints.

Semi-dry and dry papers have a wide variety of sensitivities but do not approach the printing speed of silver. They do not require totally wet developing process. Intermediate papers and cloth for ammonia machines have low light sensitivity and require long exposures to high intensity light sources.

Intermediate materials extend the utility of print making equipment beyond the field of simple duplication. Intermediates are tracing paper coated with a light-sensitive emulsion. When exposed and developed, these can be used as a new tracing from which ordinary prints can be made.

The variety of the emulsions that can be coated onto tracing paper to make intermediates is large and covers the wet, moist, and dry development processes. They produce two types of images, negative and positive. An intermediate made with a negative emulsion and exposed through a pencil drawing will look like the reverse of the drawing, with light lines on a dark background. A positive emulsion intermediate gives a print with dark traces for the original pencil lines.

The Dietzgen Company manufactures an intermediate paper coated with a negative silver emulsion, requiring wet development to produce a brown print. The trade name is Van Dyke. Larger users of blueprints often make Van Dykes of all their tracings. Since both the Van Dyke and blue print paper are negative, a blue print made from this intermediate will have blue lines and a white background.

The chief virtues of a Van Dyke:

1. Duplicates can be distributed to various locations to save wear on original tracings and minimize fire loss.

2. Tracings made on various grades of tracing paper with different printing speeds can be transferred to a medium having a uniform printing speed. This is a saving when a large number of prints is to be made on a printer requiring tracings of uniform capacity.

In making a few changes on a large drawing, an intermediate material has obvious advantages.

In the case of a Van Dyke, the chemicals used to remove silver images are often too dangerous to be handled by amateurs. Unwanted sections of the original tracing are masked or cut

out. Any lines not wanted in the final drawing are painted out on the Van Dyke with dark ink. A second Van Dyke made from this will be a positive, with brown lines on a white background, minus the lines that were painted out. Additions are made to this last print with pencil or ink to give a new tracing from which prints can be made.

Considerable time could be saved if the negative Van Dyke were eliminated and a positive reproducible print obtained directly from the original drawing.

Eastman Kodak has recently developed such a paper, Kodagraph autopositive paper. This requires wet development, and like the Van Dyke, produces a silver image which is best removed by masking or cut outs. This image is jet black.

It is also possible to obtain photographic emulsions coated onto a vellum base. This material prints a photographic image on the vellum. Additions are made with pencil or ink. Prints are obtained by the usual processes, with substantial time savings for instruction or assembly drawings.

Other moist or dry development processes also have their intermediate materials. For speed and convenience, the dry process is high on the list. A dry intermediate developed by ammonia is a positive, like the autopositive, paper. No special set-up is required to change from dry prints to dry intermediates and large drawings are reproduced easily. An additional advantage is that the brown line of this intermediate is removed by standard non-toxic eradicators. An engineer can obtain a completed intermediate by this process in much less time than by the other processes.

Storage. As a general rule, most sensitized materials other than photographic film and silver emulsion papers should not be stored longer than one month without special temperature and humidity control. Quantity purchasing discounts and quantity spoilage often go hand in hand.

Loss from spoilage of unused materials may be reduced considerably by special storage facilities and special handling. Up to three months' supply of ammonia paper can be safely stored in covered containers in a storage room at a maximum temperature of 60 deg F., with a daily or weekly supply kept in an airtight box near the printing machine. Unused portions of intermediate paper and cloth should be placed in air-tight plastic tubes immediately after cutting and returned to cold storage as soon as possible. Spoilage of loose material in hot, humid weather is exceedingly rapid and often becomes noticeable within one or two hours after exposure to the heat and humidity.

For photographic films and silver emulsion papers, the storage record is much better. These materials often remain usable long after the estimate of durability has been exceeded.

The developer and hypo used in developing silver emulsion prints are sold as packaged salts to be mixed by the user. The developer solution is not stable and soon turns brown on exposure to the air. Hypo solution is more stable and may be kept longer.

Solutions for semi-dry prints are also sold as packaged salts to be mixed by the user. They have limited durability in liquid form and darken within a few days on exposure to the air.

When considering the permanence of the finished print, distinction should be made between the durability of the paper and that of the chemical compound forming the printed image. Silver compounds are age-resistant even in strong sunlight. The compounds used in the semi-dry and dry prints have an intermediate durability when stored in folders, but turn brown when exposed to daylight and slowly fade in direct sunlight over a period of weeks. Ordinary blueprints have least durability in direct sunlight and may fade within a few hours.

Shrinkage. In some trades, the workmen obtain their dimensions by scaling prints. Prints that are developed dry shrink less than wet prints. Dry prints consistently keep their dimensions as printed and often change less than good vellum with humidity variations. Wet prints shrink unevenly, sometimes on scale in one direction while off scale in another.

1 Carrier belt is washed with water. Belt in turn washes perforated developer-tank top. Otherwise belt seam will smudge prints against the dirty tank.

2 Unwanted lines are eradicated from a dry-process intermediate. Section under the brush has been swept clean. Liquids are non-toxic, in this case.

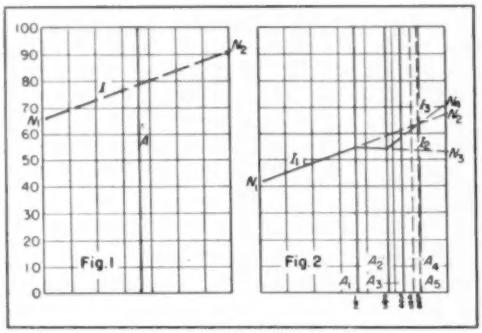
3 Light passes through the engineering drawing to sensitive paper. This paper is developed. Moist vapor is used, or the paper is swabbed or dipped.

11 Methods of Calculating

Visualization and interpolation are the common uses of graph paper. An interesting deviation from these applications is the employment of

1 SIMPLE AVERAGES—LINEAR PAPER. The scale A lies midway between the outer scales N_1 and N_2. A line drawn between two numbers on the extreme scales will intersect A at the arithmetic mean of the numbers. In the accompanying graph, Fig. 1, for example, the number 79 intersected on scales A by the index line I is the average of the numbers 66 and 92 on the outer scales.

2 MULTIPLE AVERAGES—LINEAR PAPER. Three or more terms can be averaged by succcessive operations. On Fig. 2, draw line I_1 between the first two numbers, N_1 and N_2. From the point of intersection of I_1 with A_1, run line I_2 to the third number, N_3. Follow this procedure for I_3, etc. through to the final average. A_1 is midway between N_1 and N_2. Line A_2 is twice as close to A_1 as N_2. Thus it is at odinate $\frac{2}{3}$. Succeeding A lines are at $\frac{3}{4}$, $\frac{4}{5}$ and $\frac{5}{6}$ ordinates.



4 WEIGHTED AVERAGES—HYPERBOLIC PAPER. In obtaining multiple averages by the above method, all of the averages after the first are weighted averages, in which the terms have the relative weights, 2:1, 3:1, 4:1, etc. If N_1 is to have n times the weighting of N_2, the vertical on which the average is located must be n times closer to N_1 than it is to N_2. This principle may be applied to the location of vertical lines for a much broader type of average—that in which each term may be weighted with either integral or fractional weightings. The distribution of vertical lines is again that of hyperbolic type graph paper. Thus, if the weighting assigned to N_1 (namely w_1) is 1 and that assigned to N_2 (namely w_2) is 2.5, the average $(w_1N_1 + w_2N_2)/(w_1 + w_2)$ is located on the vertical at abscissa $w_1 + w_2 = 3.5$ (Fig. 4, Part A). The average of two terms having fractional weightings can also be obtained by this method as shown in Fig. 4, part B.

The extension of this principle to the calculation of multiple weighted averages follows these steps: (1) The average obtained in the first step serves as initial point in averaging the next term. (2) Each term after the first (i.e., N_2, N_3, . . . N_n) is located on the extreme right-hand scale. (3) The nth average is located at the vertical whose designation I is the sum of the weightings of the n terms, $w_1 + w_2 + \ldots + w_n$.

Proof is obtained as before. However, substitutions for the x's of Equation 1 require definition of the ordinate scale. The displacement of vertical lines from the Y-axis of hyperbolic graph paper is given by $x = (p - 1)/p$, where p is the numeral designating the vertical line and

5 WEIGHTED SUM—HYPERBOLIC PAPER. Graphical methods of calculating simple sums are not popular, since they do not offer any advantages over mental or mechanical processes. On the other hand, the weighted sum is somewhat more difficult to compute, since it involves both multiplication and addition. Hence, there is some advantage in using the graphical method.

The sum is obtained from the weighted average by projecting the weighted average onto the N_1 scale (Y axis), using the origin of the N_2 scale as a center of projection. Proof of this relationship is derived by substituting in Eq. (1), Fig. 3, the following values:

$$y = A = \frac{(w_1 N_1 + w_2 N_2 + \ldots w_n N_n)}{(w_1 + w_2 + \ldots + w_n)}$$

$x_1 = 0 \qquad y_1 = S$

$x_2 = 1 \qquad y_2 = 0$

$x = (p - 1)/p$ where

$p = w_1 + w_2 + \ldots + w_n$

The Eq. (1) becomes

$$S = w_1 N_1 + w_2 N_2 + \ldots + w_n N_n$$

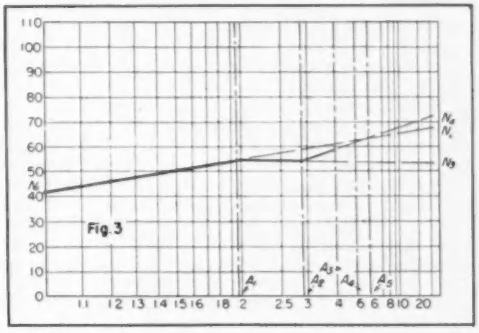
The N_1 scale is frequently too short to accommodate the necessary range for sums, but may be extended by drawing a horizontal line from $N_1 = 100$ and projecting remaining points of the N_1 scale onto this horizontal. It will be found that these points coincide with the hyperbolic rulings on that line and have values 100 times as great as the numerical designations of those lines. In Fig. 5 is shown the graphical method of obtaining weighted average and weighted sum. The problem is to determine the cost per 100 lb and the total cost of an alloy of the following composition: Tin, 146 lb at 26.00 dollar/cwt; Antimony, 74 lb at 21.50 dollars/cwt.; and Lead, 1,780

With Graph Papers

W. H. BURROWS
Faculty Research Associate
State Engineering Experiment Station
Georgia Institute of Technology

graph paper in routine calculations of a nature frequently performed with slide rules or nomographs, or by repetitive arithmetical means.

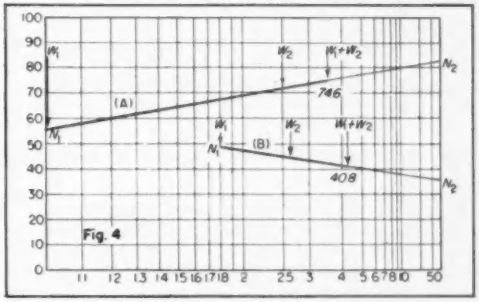
3 MULTIPLE AVERAGES—HYPERBOLIC PAPER. Hyperbolic graph paper already has its vertical lines spaced in the manner described for the preceeding figure. Consequently, this type of graph paper may be employed for multiple averages without further ruling, as demonstrated by Fig. 3. Proof of this relationship can be obtained from the general equation for a straight line that passes through points x_1, y_1 and x_2 y_2. This may be written as $y(x_2 - x_1) + y_1(x - x_2) - y_2(x + x_1) = 0$ (Eq. 1). By successive substitutions in this equation; the expression $A_n = (N_1 + N_2 + N_3 \ldots + N_n)/n$ will be arrived at. This is recognized as the equation for a numerical average. In developing Eq. 1, remember that several index lines are involved and different values are to be substituted at each step. The index line between A_1 and N_3 is located by $x_1 = \frac{1}{2}$, $y_1 = A_1$, $x = \frac{2}{3}$, $y = A_2$, and $y_2 = N_3$.



where the extreme right-hand vertical ($p = \infty$) is unit distance from the Y-axis. The expression for this general relationship then becomes $A = (w_1N_1 + w_2N_2 + \ldots + w_nN_n)/(w_1 + w_2 + \ldots + w_n)$.

A later illustration will point out the real advantage to be gained by use of graph papers for calculation. If a formula, such as that given in the illustrative example below, can be set up on graph paper, repeated solutions of the formula for different values of the variables are made quickly and easily. The low cost of setting up the graph paper makes possible their use in applications where the cost of other types of specially prepared calculators such as slide rules could not be justified economically.

Another factor favoring the use of graph papers in repetitive calculations is time. Graphs can be set up quickly.



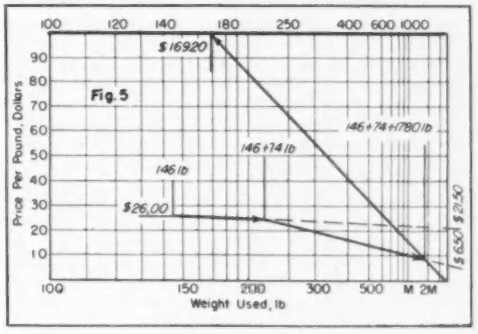
lb at 6.50 dollars/cwt. Cost per 100 lb: 8.46 dollars. Total Cost: 169.20 dollars.

The latter example alone should point out the usefulness of this method for obtaining weighted averages with hyperbolic paper. It could be used for estimating material or product cost before manufacture.

6 QUADRATIC EQUATIONS—HYPERBOLIC PAPER. The equation of a line intersecting the N_1 scale of hyperbolic coordinates at b and the N_2 scale at a is $x = (y - b)/(a - b)$. But the value of x in hyperbolic coordinates is $x = (p - 1)/p$. Hence,

$$p = (b - a)/(y - a). \qquad (2)$$

In Eq. (2), substitutions are introduced as follows:



$a = -A$, $b = -(A + B)$, and $p = y$. The resulting equation is $y^2 + Ay + B = 0$, which is of standard quadratic form. Consequently, solution of a quadratic equation may be realized by this procedure. First, locate the value of $-A$ on the N_2 scale (right-hand) and $-(A + B)$ on the N_1 scale (left-hand). Lay a straightedge between these two points. Then, scan this line to find the points at which $y = p$. These values of y are roots of the equation. By way of illustration, Fig. 6 shows the roots of the quadratic equation $y^2 - 5y + 6 = 0$ to be $+2$ and $+3$.

This method realizes only positive roots. Negative roots can be found by locating $a = -A$ on the N_2 scale and $b = -(A - B)$ on the N_1 scale. The line is then scanned for the value of p which is equal to $-y$, the negative root. In Fig. 7, the equation $y^2 + y - 6 = 0$ is plotted, yielding the roots $+2$ and -3.

In addition to the possibility of there being two positive roots, two negative roots, or one positive root and one negative root, there are two other results to be anticipated. The two roots may be identical, in which case the index lines connecting $-A$ on the N_2 scale with $-(A - B)$ and $-(A + B)$ on the N_1 scale are identical. This is possible only when $B = 0$. It is also possible to have two imaginary roots, in which case this method fails to realize a solution of the equation. One knows, of course, that it is impossible for a quadratic equation to have one real and one imaginary root.

Thus far, this method has been confined to roots of an order of magnitude of numbers 0 to 10, inclusive. It may be altered slightly to determine very large or very small roots. The N_1 and N_2 scales may be altered simultaneously by multiplying each of their scale points by any desired factor (such as 2, 10, or 0.1), and this change will have no effect upon the validity of the method. For the numerical designations of the hyperbolic (horizontal) scale to have the same order of magnitude, it is necessary that they, too, be multiplied by that same factor. This, however, would produce erroneous results, unless substitutions in keeping with this change were made. The required substitutions are $a = -A$, $b = -(A + B/r)$ for positive roots and $b = -(A - B/r)$ for negative roots, r being the factor by which the numerical designations of all three scales are multiplied. The scales in Fig. 8 were renumbered to adapt this method to quadratic equations with large roots.

The location of roots by these methods is greatly facilitated by drawing a curve through the points on which y and p have equal values. Two forms of reduced cubic equations may be solved by this method. The equation $y^3 + Ay^2 + B = 0$ is solved by locating the same values as previously on the N_1 and N_2 scales and finding the point on the index line at which $p = y^2$. The equation $y^3 + Ay + B = 0$ is solved in like manner, except that the point to be located is the value of p at which $y = p^2$. If extensive application is to be made of this method, it is desirable to draw curves through the required points for these cases, also. Fig. 9 demonstrates the solution of reduced cubic equations. Curve A depicts the equation $y^3 + Ay^2 + B = 0$. Curve B is for equation $y^3 + Ay + B = 0$.

In similar manner, it is possible to construct curves for polynomials of higher or fractional powers, if only two powers of the unknown are involved. If $u^n + Au^m + B = 0$ is the polynomial, the curve is plotted for the points $p = y^{m/(n-m)}$, using the method of Section 15 or 18 for evaluating p. The values of A and B determine the position of the index line exactly as before, and the points of intersection of the resulting index line with the curve is at the point $p = u^m$. For cases in which $m \neq 1$, the corresponding root of the equation may be obtained by the method of fractional exponents given in Section 15 or 18. If desired, these values may be entered on the points of the curve to further expedite solution of the equation.

7 PROPORTIONALITY—LINEAR PAPER **(First Method).** The simplest method of establishing proportionality between two sets of number using linear paper is illustrated in Fig. 10. In this problem, it is desired to determine the various combinations of individual gear sizes of a particular pitch that will produce a wanted speed change ratio. First step is to mark both the horizontal and vertical scales of the linear graph paper with the stock sizes of gears available in the specified pitch. At each point on both scales, perpendicular lines are erected. The intersection of each vertical line with a horizontal line indicates the ratio between the gears represented by the two lines. To determine the various gear sets yielding the wanted ratio, a line is drawn between the origin and any one intersection corresponding to this ratio. All other points of intersection that lie on the resulting line represent identical ratios. From Fig. 10 it can be seen that 8 different combinations of stock gears will have a 2:3 ratio. Although the chosen example is more or less elementary, it is apparent that this method is a potential time saver for many applications. Similarity of triangles is sufficient proof of the proportionality established by this method. It may be observed also that substitution of the value $b = 0$ in the straight line equation $y = mx + b$ yields the relationship $m = y/x$. Since m, the slope of the line is constant the ratio y/x is also constant for all points on that line.

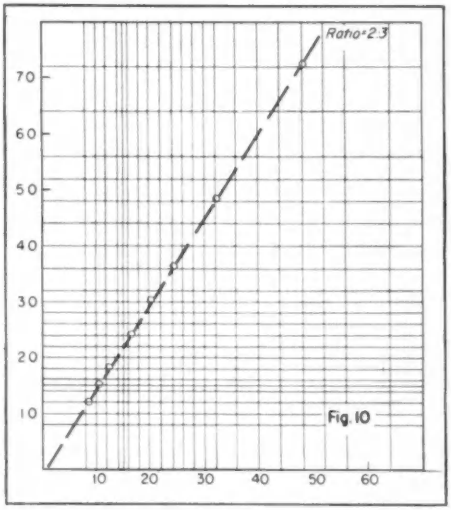
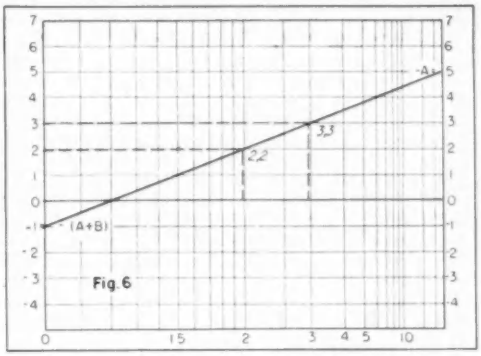
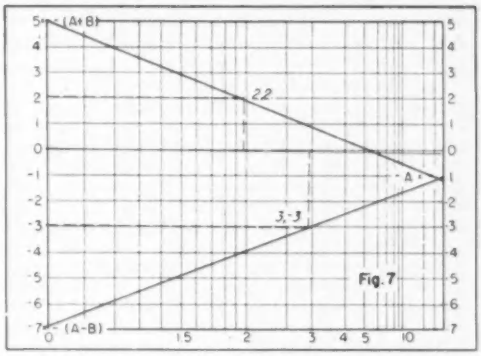
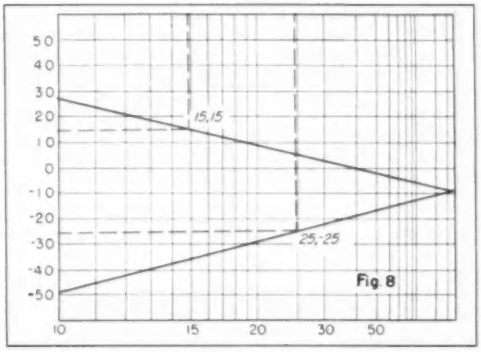
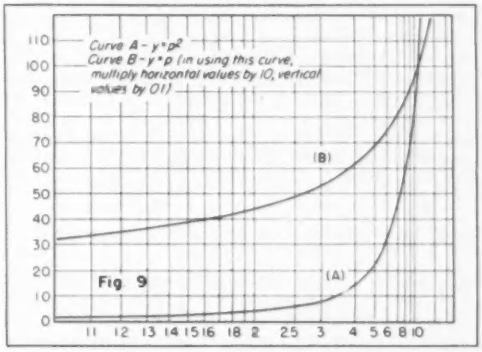


Fig. 10



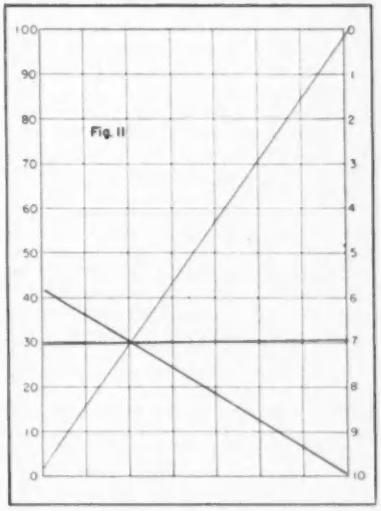






8 Proportionality—Linear Paper (Second Method). The method described in section 7 above has its drawbacks. It serves very well for cases such as the described selection of gear combinations, where a chart of stock sizes once prepared is used repeatedly. But when applied to more general cases, it becomes cumbersome. The eye must follow two index lines at right angles to each other, rather than a single straight index line. This naturally requires somewhat more time and presents additional opportunities for misreading. Accordingly, a second method about to be described may prove to be of advantage in the majority of cases.

As the first step in this second method of obtaining proportionality, a diagonal line is drawn from the lower left-hand corner of the linear chart to its upper right-hand corner. The right-and left-hand borderlines of the chart are then scaled with values, their origins lying on the diagonal. That is, the left-hand scale reads upward, the right-hand scale, downward. The orders of magnitude of scale units need not be identical on the two scales. Then, any pair of index lines which intersect as the diagonal will, if extended, pass through points on the two border scales which are proportional. To demonstrate this method, Fig. 11 has been prepared, indicating proportionality with two index lines intersecting at the diagonal. The ratios involved are 7:10 and 28:40. In this case, too, this relationship could be proven from the similarity of triangles. A second proof could be obtained from the straight line equation $y(x_2 - x_1) + y_2(x - x_1) - y_2(x + x_1) = 0$. Substituting in this equation $x_1 = x_1' = 0$, $x_2 = x_2' = 1$, $x = x'$, and



$y = y'$ (the latter being the coordinates of the point of intersection), it is obvious from the equations of the two lines that $y_1'/y_1 = y_2'/y_2$. In this application, the diagonal line is considered to be the X axis, with y_1 and y_1' lying above the axis, y_2 and y_2' below that axis.

It is often desirable, in the interest of accuracy, to limit the vertical scales to relatively small ranges, in which case it is very likely that the origins of these scales will be inaccessible. In this case, construction of the diagonal line becomes a problem. The analytical solution of this problem consists of the following steps: (1) Using the values of their right-hand and left-hand scale marks, derive the equations of the upper and lower border lines from Eq. (1). (2) From these equations, determine the value of x when $y = 0$. This will be the value of x at the point where the diagonal intersects that border line. (3) Draw the diagonal line through the two points thus determined.

The graphical solution of this problem follows. (1) Draw two pairs of index lines corresponding to known proportionalities, one pair intersecting in a point near the bottom, the other in a point near the top of the chart. (2) Draw the diagonal line through these two points of intersection. A little experience with this method shows the analytical method to be preferable.

A great many engineering formulas may be expressed as proportionalities, and give rise to a standard nomographic chart of this form, known variously as the *N*-type, *Z* type, or *H*-type chart.

9 Products—Linear or Hyperbolic Paper. Multiplication can also be performed with graph papers. A discussion of this subject logically follows the foregoing treatment because proportionality is a form of multiplication. This is readily understood from the basic axiom that the product of the means in a proportion is equal to the product of the extremes. If one of the extremes is equal to unity, the other extreme is the product of the means. Thus, if $a:b = c:d$, and if $d = 1$, then $a = bc$. A chart for multiplication can be constructed from the chart for proportionality described in section 8, above. Draw a family of lines from 1 on the left-hand scale to the various numbers on the right-hand scale. The intersections of these lines with the diagonal line are then marked with numerals corresponding with those on the right-hand scale. The construction of this chart and its application in determining a product are illustrated in Fig. 12. Line *1* shows the product of 8.2 x 3.5 to be 28.7.

The same device might be constructed using the vertical border scales of hyperbolic graph paper. Upon subdividing the diagonal scale, it will be discovered that the scale points correspond with the vertical rulings of that paper, it being necessary only to change the numerical designations. Accordingly, a chart for products may be more simply constructed on hyperbolic paper than on linear paper. A chart for multiplication laid on hyperbolic graph paper is shown in Fig. 13.

Once constructed, such a chart serves equally well for both products and proportionality. Indeed, its use in

10 Ratio, Proportion and Multiplication—Semilogarithmic Paper. In Fig. 14 can be seen several operations which may be performed with straight index lines on semilogarithmic paper. These operations include proportionality, products, squares, square roots and geometric mean. On this paper horizontal rulings are logarithmic. Hence, substitutions for y in the equations for a straight line are of the form $y = \log u$. The proofs of these relationships are straightforward. Two forms of proportionality are illustrated. The parallel lines *B* and *D* are employed to show the proportionality 8:128 = 250:4000. The lines *B* and *C*, intersecting at the midpoint, illustrate the proportionality 8:64 = 31.3:250. Since the proportionality $a:b = c:d$ may be written $a = b \times c/d$, this method may be employed for combined multiplication and division. In Fig. 14 this operation is illustrated in the lines *B* and *C* where $X = 64 \times 31.3/250 = 8.0$. A simple product results if the denominator of this expression is 1. Thus, using lines *A* and *C*, 64 x 31.3 = 2000. Likewise, if one of the numerators is 1, a simple division is performed, as with lines *A* and *B*, 250/8 = 31.3.

In the same figure, each line crossing the three vertical scales computes a geometric mean. Line *D*, for instance, shows the geometric mean of 128 and 4000 to be 715, which lies at the midpoint of that line-segment. That is, 128:715 = 715:4000. Many engineering formulas may be expressed as geometric mean relationships. An example is the expression for modulus of resilience, U_r, for longitudinal stress, $U_r = \frac{1}{2} S_r^2/E$, which may be written: $U_r:S_r = S_r:2E$. A line drawn through $2E$ on a border scale and S_r on the midline scale will intersect the other border scale at the value of U_r. On line A, the relationship is 1:44.7 = 44.7:2000, which may be read $(44.7)^2 = 2000$. This method, then gives squares and square roots of numbers, as well as geometric means, products, and proportionalities.

It will be noted that the discussions in this article are limited to four common types of graph paper. The types involved are linear, hyperbolic, logarithmic and semilogarithmic. But the principles employed may be extended to other types such as triangular paper and polar paper. For each type of paper, the axes have their characteristic equations (as x = a log v, etc.), which, with the equations of the index lines, give rise to the solution of specific problems.

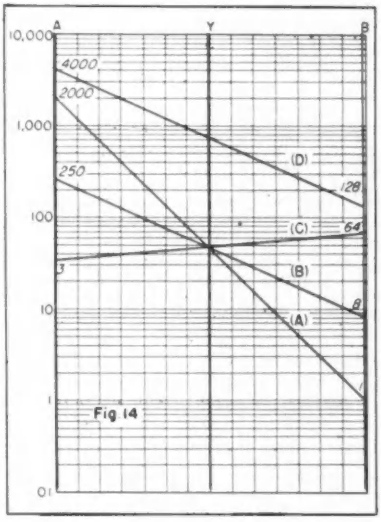
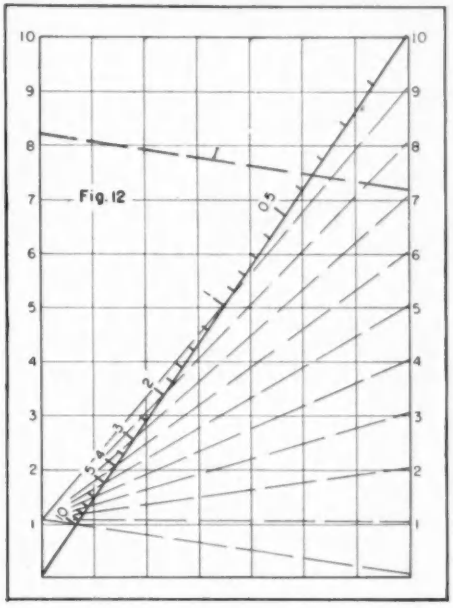
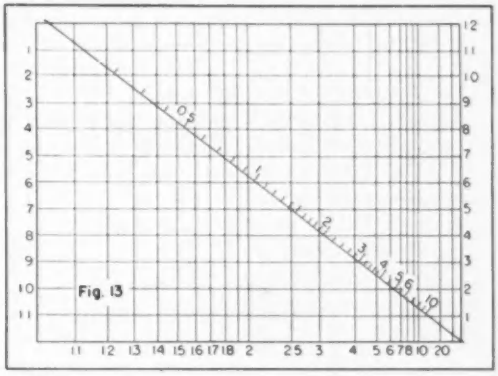


Fig 14



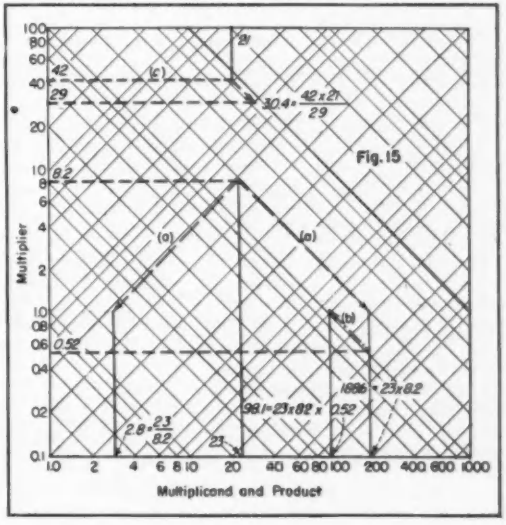
proportionality problems serves to demonstrate the method of division with this chart—a technique which will be obvious as soon as applied.

The reader may wish to examine the examples given in any textbook on nomography to see how versatile these methods are. In this connection, it should be pointed out that the subject of calculating with graph papers is vast in scope. There are many books in existence that are designed to provide an intensive knowledge of nomography and its application to practical problems.



11 MULTIPLICATION—LOGARITHMIC PAPER. The rulings of both axis of this type of graph paper are logarithmic. Consequently, equation 1 becomes log $y = \log b + m \log x$, or $b = y \times x^{-m}$. Application of this relationship provides a method of multiplication which is frequently used by designers of engineering charts. If $m = -1$, then $b = y \times x$, while, if $m = 1$, $b = y/x$. Thus, motion along a line with a slope of -1 constitutes multiplication, while motion along a line with a slope of $+1$ constitutes division. Motion is understood here to be in the direction of the line $y = 1$. In Fig. 15 these operations are illustrated by the product and quotient evaluated in Part (a). In Fig. 15, Part (b) the method is applied in succession to evaluate a combined multiplication and division. Obviously, the method could be applied as well to a series of terms. If motion along the diagonal lines is made away from the line $y = 1$, rather than towards that line, the operations of multiplication and division are reversed. This being the case, it is possible to eliminate one set of diagonals, using say only those of slope -1, and at the same time to have at hand a ready method of performing combined multiplication and division operations without reference to the line $y = 1$. This is shown in Fig. 15, Part (c).

The popularity of this type of chart is due largely to the following advantages over the slide rule. (1) The position of the decimal point is automatically determined. (2) Constants which frequently appear in computations are easily marked on the chart as vertical or horizontal lines. (3) The rapidity with which calculations may be accomplished is greatly increased by the use of a 45 deg triangle, which makes the diagonal rulings entirely unnecessary.



A second article on this subject will appear in a later issue of PRODUCT ENGINEERING. The author will describe in detail several additional calculations that can be performed on logarithmic and semi-logarithmic graph paper. The latter types of paper are the most versatile of the group.

Calculating the Energy Losses In Hydraulic Systems

Graphical methods of analyses that save time and make tedious mathematical calculations unnecessary. Charts for frictional and energy loss coefficients in AN hydraulic fittings, circular pipes, and other elements used in hydraulic circuits.

NILS M. SVERDRUP
Hydraulic Engineer
Aerojet Engineering Corp.

TO PROPERLY DESIGN A HYDRAULIC SYSTEM one of the first requisites is to accurately know each of the losses in the entire circuit. These losses are dependent on the many elements that comprise the system: length and shape of the lines, fittings, connections, valves and orifices. With an accurate estimate of the anticipated energy losses, a designer can readily determine the proper size of pump, motor and lines for a specific application.

Theory of Fluid Flow

Energy losses are affected by many factors such as: type of flow, wall friction in pipes, viscosity of fluid, and resistance due to bends and fittings. This energy is converted into heat and cannot be recovered in useful form. Such dissipated energy in any fluid passage is conveniently expressed mathematically as a function of the velocity head:

$$H = \frac{1}{2g} \Sigma\, \varepsilon_n V_n^2 + 0.01553 \Sigma\, \varepsilon_n V_n^2 \quad (1)$$

where H is the total loss in head (ft), g the gravitational acceleration (ft per sec^2), ε_n is the coefficient of energy loss of each section of the fluid passage, and V_n is the fluid velocity at each section (ft per sec). A value of this coefficient is required for each hydraulic fitting and bend as well as for friction in straight pipe.

Friction Losses in Fluid Lines

In practical hydraulic engineering, the fluid velocity in a passage is usually unknown. The rate of flow, however, can be readily measured. Consequently, it is more convenient to eliminate the velocity terms and express V (fps) as a function of the rate of flow G (U. S. gpm) and the pipe diameter D (in.). Substituting the flow relation: $V = 0.4085\ G\ D^{-2}$ in Eq (1), gives the loss in head,

$$H = 2.591 \times 10^{-3}\, G^2 \Sigma\, \varepsilon_n\, D_n^{-4} \quad (2)$$

The loss in head H (ft) and pressure loss P (psi) are related by: $H = 2.308\ P/S$; where S is the specific gravity of the fluid. Substituting

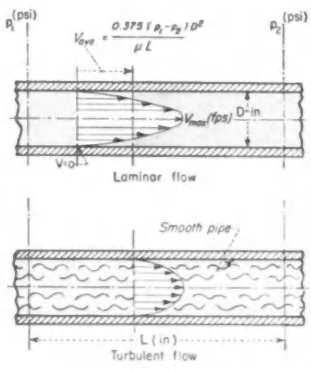


Fig. 1—The mean velocity of a liquid flowing in a tube depends on the flow: whether laminar or turbulent.

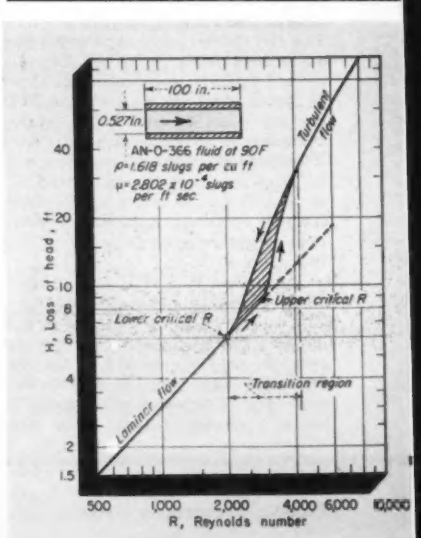


Fig. 2—The energy losses due to friction are greatly increased when the fluid is flowing turbulently as compared to laminar flow.

this in Eq (2), the pressure loss is:

$$P = 1.123 \times 10^{-3} G^2 S \Sigma e_n D_n^{-4} \quad (3)$$

The pressure at any point p_2 can be found from Bernoulli's energy equation by properly substituting P for the total energy loss term H:

$$p_2 = (p_1 - P) - 1.078 \times 10^{-4} \times \gamma (V_2^2 - V_1^2) + 6.944 \times 10^{-3} \gamma h \quad (4)$$

where p_1, p_2 is the pressure (psi) and V_1, V_2 is the fluid velocity (fps) at two particular points (1) and (2) along the flow line; and γ is the specific weight of the fluid (lb per cu ft). In this equation, the second term on the right-hand side represents the variation in pressure due to a change in velocity, and the third term represents the intensity of pressure due to the potential head h. Eq (4) can be expressed in terms of the rate of flow, pipe diameters and specific gravity as follows:

$$p_2 = (p_1 - P) - 1.123 \times 10^{-3} \times S G^2 (D_2^{-4} - D_1^{-4}) + 0.433 S h \quad (5)$$

Pressure differential $(p_1 - p_2)$ between any two points in a hydraulic system can be obtained by rearranging Eqs (4) or (5); it should not be confused with the pressure loss due to the dissipation of energy. However under certain conditions, when h is zero and V_1 equals V_2, the pressure differential is equal to the pressure loss.

Nature of Flow

The type of flow that exists in a line, as shown in Fig. 1, can be determined by means of a dimensionless ratio R. This ratio, called Reynolds number is:

$$R = \frac{\rho VD}{12\mu} = \frac{VD}{12\nu} = 3162.419 \frac{G}{\nu_1 D} \quad (6)$$

where ρ is the density (slugs per cu ft), V the velocity (fps), and μ the absolute viscosity of the fluid (slugs per ft sec); D is the pipe diameter (in.); ν is the kinematic viscosity of the fluid (sq ft per sec) while ν_1 is the kinematic viscosity in centistokes; and G the rate of flow (U. S. gpm). At this point the flow becomes unstable then as the velocity is further increased, the character of flow is turtion losses of a long straight smooth pipe is graphically shown in Fig. 2. For low values of Reynolds number, the flow is laminar and this pattern continues as the velocity is increased until the upper critical value is reached. At this point the flow becomes unstable then as the velocity is further increased, the character of flow is turbulent and the friction rate rapidly increases. Once in the turbulent region, this type of flow prevails until the velocity is reduced to the lower critical value of R. At this point, the flow pattern reverts back to the laminar type. Between this range of Reynolds numbers, where the flow may be either laminar or turbulent, is called the transition region. If there were bends or fittings in the line, the particular critical value of R would be lower; however, the flow characteristics illustrated would be the same.

There appears to be no definite limit in the value of the upper critical R; laminar flow has been maintained for values of Reynolds number as high as 50,000 depending upon the care taken to prevent initial disturbing effects such as pipe bends and fittings. However, under normal conditions laminar flow does not prevail for values of R above 2,400 to 3,000. There is a lower critical Reynolds number below which turbulent flow cannot persist; this value is about 2,000 for flow in straight pipes. In hydraulic installations where the flow is usually disturbed by considerable bends and fittings, the flow may be turbulent for values of R as low as 1,000.

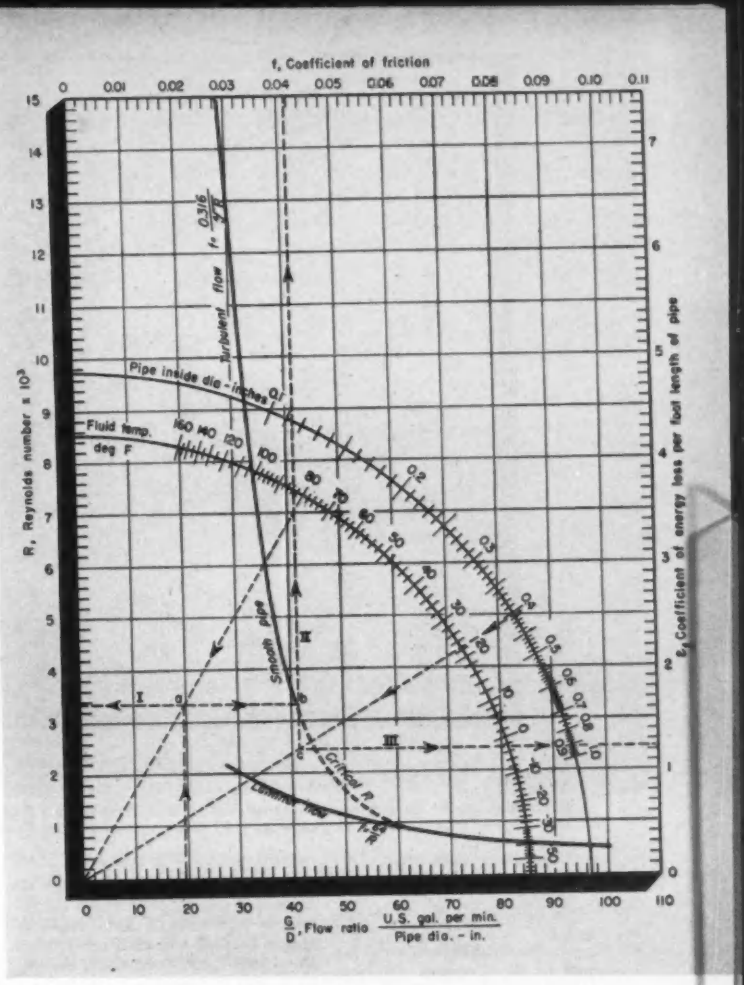


Fig. 3—Reynolds number, coefficients of friction and energy loss for laminar or turbulent flow in pipes of a hydraulic fluid (AN-0-366) at different temperatures.

Energy Losses in Piping

Laminar Flow: If the fluid in a straight pipe is laminar, the loss in head can be expressed by:

$$H = f \frac{L}{D} \times \frac{V^2}{2g} \quad (7)$$

where, f is the coefficient of friction; and: $f = \frac{64}{R}$; L and D are the length and diameter of pipe respectively (in.). Eq (7) is based on the Hagen-Poiseuille law; it can be further simplified

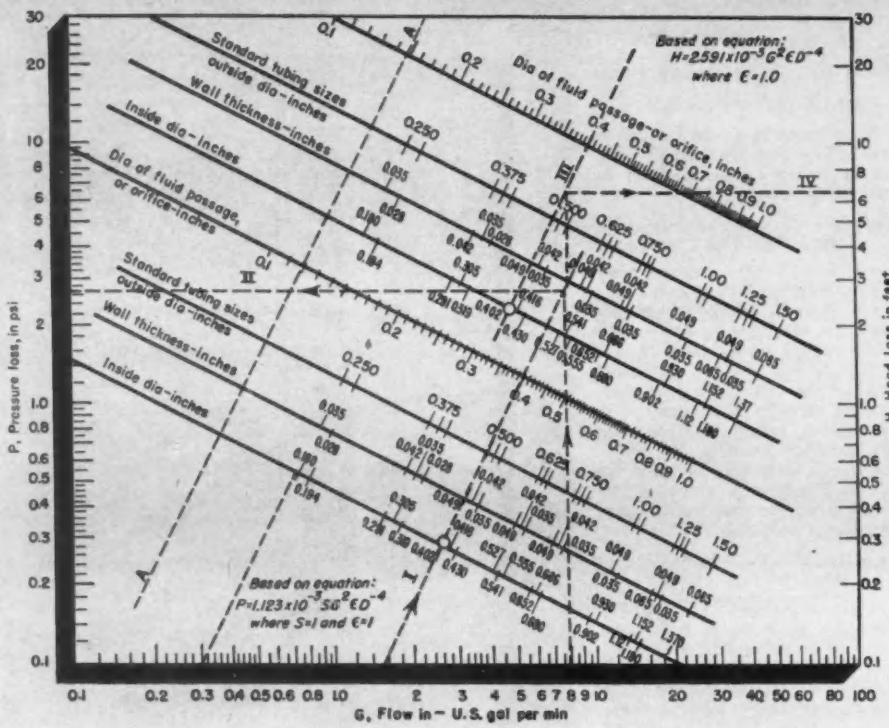


Fig. 4—Graph to find: Loss of head H or Pressure Loss P of a hydraulic fluid flowing in circular pipes or orifices. Lower four inclined scales are for finding P while the upper inclined scales apply to H.

by using the coefficient of energy loss,

$$\epsilon_f = f \frac{L}{D} \qquad (7A)$$

For laminar flow, coefficient ϵ_f is independent of the roughness of pipe and can be used in Eqs (2) and (3).

Turbulent Flow: Experiments have shown that the roughness of pipe has a decided effect on the resistance to turbulent flow. Due to the complexity of this type of flow along with the difficulty in establishing a numerical scale of roughness, a satisfactory theoretical equation for computing the friction coefficient so far has not been developed. However, by analyzing experimental data, Blasius found that for *smooth pipes* the friction coefficient f can be expressed by:

$$f = \frac{0.316}{\sqrt[4]{R}} \qquad (7B)$$

This coefficient can be used in Eqs (7) and (7A) for values of Reynolds number up to about 100,000.

Graphical Solution

Calculating the energy losses in hydraulic lines can be performed by using the previous equations. However a more rapid and convenient method is possible by means of the graphs in Figs. 3 and 4. To use the chart in Fig. 3 simply requires the following data: rate of flow, inside diameter of pipe and fluid temperature. This graph solves: Reynolds number, coefficient of friction and the coefficient of energy loss. Although this chart is based on a particular hydraulic fluid, (AN-O-366), it can be applied to other fluids by a simple conversion which will be given later. By means of Fig. 4, the pressure loss and the loss in head can be determined. The information required is: rate of flow, pipe diameter, specific gravity of the fluid and the coefficient of energy loss (from Fig. 3).

EXAMPLE 1: A hydraulic fluid (AN-O-366) at 80 F flows through an 0.402 in. ID smooth pipe 160 in. long at 8 U. S. gpm. Find Reynolds number, coefficient of friction, and the coefficient of energy loss.

SOLUTION: In Fig. 3 the intersection of the flow ratio line (G/D equals 8/0.402 or 19.9) and a radial line from 80 F on the temperature scale establishes point *a*. Line I drawn from point *a* determines Reynolds number R of 3390. Projecting line I to the flow curve (point *b*) indicates that the flow is turbulent. Line II from point *b* vertically upward to the coefficient of friction scale, establishes f as 0.0415. The intersection of Line II and a radial line from the Pipe Inside Diameter Scale (0.402) determines point *c*. Horizontal line III from *c* projected to the energy loss scale gives a value for ϵ_f of 1.24 per foot of pipe. Therefore, for 160 in. of pipe,

$$\epsilon_f = 1.24 \times \frac{160}{12} = 16.5$$

To calculate the pressure loss P or loss in head H, Fig. 4 is used. This chart is divided into two sections. The lower inclined scales determine the pressure loss and are based on Eq (3). The four upper scales are based on Eq (2) for the loss in head. Note that the inclined scales have dimensions of standard tubing. This chart is predicated on a fluid whose specific gravity S equals unity and that the coefficient of energy loss ϵ is equal to one. Thus, any values obtained from this chart must be multiplied by the actual values of S and ϵ to determine the final answer.

EXAMPLE 2: With data in Example 1, find: pressure loss P and loss in head H in the line 160 in. long.

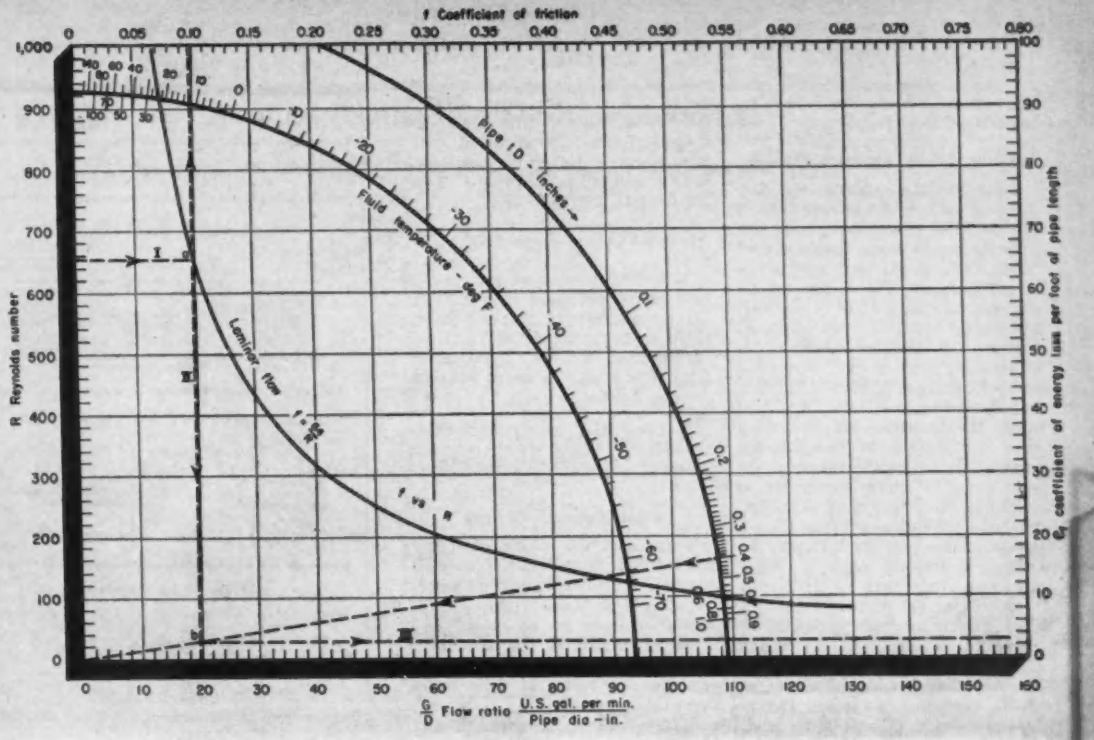

f Coefficient of friction
R Reynolds number
Pipe ID - Inches
Fluid temperature - deg F
Laminar flow
f vs R
Coefficient of energy loss per foot of pipe length
G/D Flow ratio U.S. gal. per min. / Pipe dia - in.

Fig. 5—For laminar flow through circular pipes, diagram gives Reynolds number R, coefficient of friction f and coefficient of energy loss ϵ for AN-0-366 fluid at various temperatures and can be also used for other fluids.

SOLUTION: Parallel to Line *A-A*, in Fig. 4, Line I is drawn through point 0.402 in. on the inside diameter scale to intersect the rate of flow line. (Note that line I coincides with a wall thickness of 0.049 in. and an *O.D.* of 0.500 in.) This intersection establishes line II. From line II, the pressure loss P is found to be 2.75 psi. Since the specific gravity of this fluid S equals 0.838 (see the Specific Gravity Curve on p 173) and ϵ_{f1} is 16.5 (from Example 1), this pressure loss must be modified. The actual pressure loss,

$$P_1 = (\text{Chart } P) \times S \times \epsilon_{f1} = 2.75 \times 0.838 \times 16.5 = 38 \text{ psi.}$$

To determine the loss in head, the upper inclined scales are used in a similar manner to that of the lower scales. Line III is drawn parallel to Line *A-A* through a point on the tubing size scale; the intersection of line III and the flow rate establishes line IV which determines the loss in head H which is 6.3 ft. Since this chart is based on ϵ being unity, it must be multiplied by the proper value of ϵ. Thus, the actual loss in head,

$$H_1 = (\text{Chart } H) \times \epsilon_{f1} = 6.3 \times 16.5 = 104 \text{ ft of fluid}$$

To use Fig. 3 for other hydraulic fluids, the value of Reynolds number could first be determined by Eq (6). Using this calculated value of R, the subsequent steps in the graphical solution would be similar to those of the example given. The flow curves (Figs. 3 and 5) represent two equations: first, the coefficient of friction is expressed as a function of Reynolds number (whether laminar or turbulent) and second, the coefficient of energy loss ϵ_f is given as a function of the friction factor f and the pipe diameter D.

Instead of computing Reynolds number for a particular fluid, this chart can be used to determine R for the AN-0-366 fluid and then modify this value to compensate for the properties of the particular fluid being used. This conversion can be made by using the following relationship:

$$\frac{R_1}{R} = \frac{\mu \rho_1}{\mu_1 \rho} = \frac{\nu}{\nu_1} \qquad (8)$$

where R, μ, ρ, and ν correspond to the AN-0-366 fluid and R_1, μ_1, ρ_1, and ν_1 are the values of the specific fluid to be used. The viscosity chart on p 173 should be useful to find the physical properties of a few common hydraulic fluids. With a proper value of R, the steps would be similar to those of the previous examples.

EXAMPLE 3: Determine the energy loss in Example 1 if the fluid used is AN-0-6a at 20 F.

SOLUTION: From viscosity chart, p 173,

ν = 18.6 centistokes for AN-0-366 at 80 F
ν_1 = 96 centistokes for AN-0-6a at 20 F
R = 3390 (from Example 1)

Reynolds number for this fluid is obtained by solving Eq (8):

$$R_1 = \frac{18.6}{96} \times 3390 = 656$$

The chart in Fig. 5 (an enlarged part of Fig. 3) is used for laminar flow problems. The calculated value of Reynolds number is projected (line I) to intersect the flow line at point *a*. Line II drawn upward from *a* determines the friction factor f of 0.098. Line II also intersects the radial line from the Pipe Diameter Scale at point *b*. Line III from *b* to the Coefficient of Energy Loss Scale determines ϵ_f which is 3.0 per ft. Since the pipe is 160/12 ft. the coefficient of energy loss,

$$\epsilon_{f1} = 3.0 \times \frac{160}{12} = 40$$

The pressure loss and loss in head can be obtained from Fig. 4.

Energy Losses Through Fittings

Since hydraulic systems are characterized more by the fittings, than by straight pipe, it is important to consider the energy losses due to elbows, bends, tees, unions, and contractions or enlargements. Fig. 6 lists the coefficients of energy loss ε for AN type fittings with AN-0-366 Hydraulic fluid at 75 F. Included are the effects of velocity; note, in most cases, that the coefficient of energy loss diminishes with increasing flow rates. For pipe bends, the magnitude of the energy losses are determined by: (1) the friction loss due to the length of the bend and (2) energy losses due to change in the direction of flow. Experiments indicate that losses from a change in direction depend upon the ratio R/D and the angle of bend; this loss is a minimum for R/D equal to about 4.0. The table in Fig. 6(F) gives values for the coefficient of energy loss as a result of the change in direction of flow for various bends. This coefficient is added to the (frictional) coefficient of energy loss ε_f due to the length of pipe in the bend.

EXAMPLE 4: A hydraulic fluid (AN-0-366) at 75 F is flowing at the rate of 15 U. S. gpm in a pipe with an $OD = 0.750$ in. and a wall thickness of 0.042 in. Compare the resistance of flow between an AN-821-12, 90 deg elbow (D is 0.609 in.) and a 90 deg pipe bend having a 6 in. radius.

SOLUTION: From Fig. 6(A), with the elbow D of 0.609 in., ε is found to be 2.1. For the bend, R/D is 6/0.666 or 9.0 and from Fig. 6(F) ε equals 0.300. The frictional coefficient of energy loss of the pipe in the bend ε_f is 0.740 per ft of pipe. Thus, for the total length of bend,

$$\varepsilon_{fl} = 0.740 \times \frac{12\pi}{12 \times 4} = 0.580$$

With this, the pressure loss for each type can be calculated from Eq (3). The summation term, $\Sigma\, \varepsilon_n\, D_n^{-4}$ for the elbow is 2.1×0.609^{-4} or 15.27 and for the bend, $\Sigma\, \varepsilon_n\, D_n^{-4}$ is $(0.300 + 0.580) \times 0.666^{-4}$ or 4.47. Thus the pressure loss for each is:

$$P_{elbow} = 1.123 \times 10^{-8} \times 0.840 \times 15^2 \times (15.27) = 3.24 \text{ psi}$$

$$P_{bend} = 1.123 \times 10^{-8} \times 0.840 \times 15^2 \times (4.47) = 0.95 \text{ psi}$$

Flow Through Orifices

To calculate the volume of a fluid flowing through an orifice, Torricelli's equation is commonly used with proper coefficients. In Table I(A), average values are listed for contraction and discharge coefficients that should be useful. Table I(B) and (C) gives recommended values of these coefficients for the rounded-edge, thick-wall, and short-tube orifice when flowing full.

Since orifice coefficients vary with the diameter, finish, wall thickness velocity and character of flow, the actual value of the coefficients should be experimentally determined for extreme accuracy.

The flow equation will be more convenient if it is expressed in terms of flow rates and diameters; this is illustrated in Table I Eq (9). The

TABLE I

Type of orifice	
Thin-wall, sharp edged	A
Thick-wall, short tube	B
Round or bell mouth	C
Divided flow	D

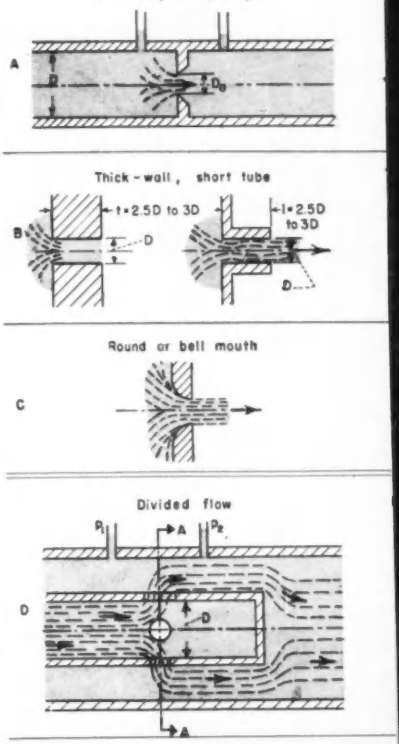
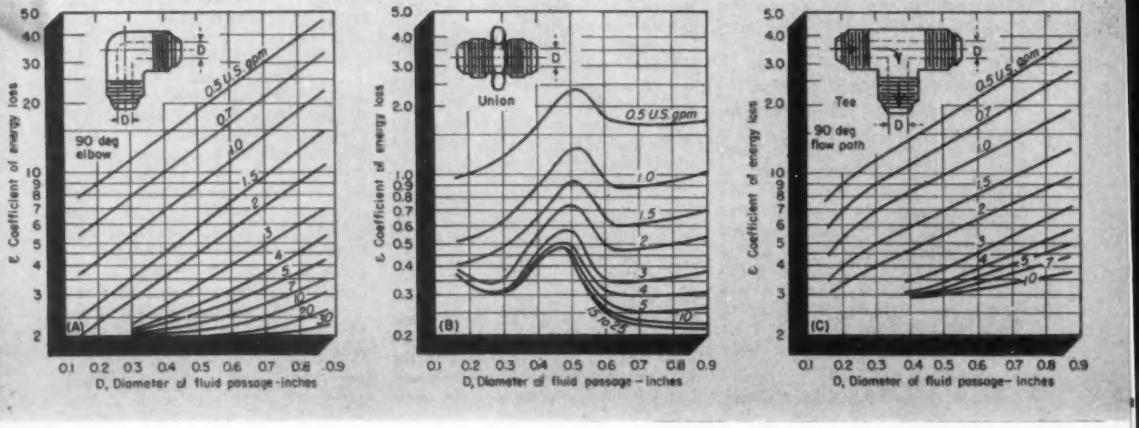


Fig. 6—Coefficients of energy loss ε for several common hydraulic fittings of the AN type. These values are based on an AN-0-366 fluid at 75 F.

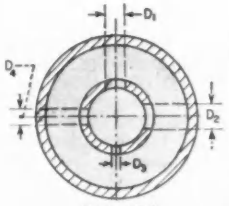


DISCHARGE COEFFICIENTS AND EQUATIONS FOR VARIOUS TYPES OF ORIFICES

C_c Coefficient of contraction Average values		C_D Coefficient of discharge Average values			Flow rate in U.S. gpm
$\frac{D_0}{D}$ = Orifice dia / Pipe dia	C_c	$\frac{D_2}{D}$	Laminar R = 2,000	Turbulent R=10,000 to 20,000	
0.25 to 0.40	0.64	0.3	0.64	0.62	$G = 29.843\ C_D\ D_0^2 \sqrt{\frac{P_1 - P_2}{S}} \times \phi_1$ (9)
0.7	0.68	0.5	0.67	0.64	
0.8	0.73	0.7	0.71	0.66	
0.9	0.82				

Where,
G = Flow rate U.S. gpm
D = Pipe dia., in.
D_0 = Orifice dia., in.
$(P_1 - P_2)$ = Pressure differential across orifice (psi)
S = Specific gravity of fluid
ϕ_1 = Velocity of approach factor $= \frac{1}{\sqrt{1 - C_0^2 (\frac{D_0}{D})^4}}$ (9A)

$C_c = 1$	C_D = 0.80 to 0.82	Special case: When ratio $\frac{D_0}{D} \leq 0.3$, $\phi_1 \rightarrow 1.0$ and can be neglected
$C_c = 1$	C_D = 0.98 to 0.99	



Section A-A

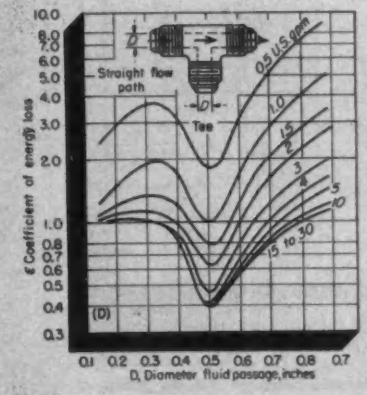
C_{D_2} = approx 0.650

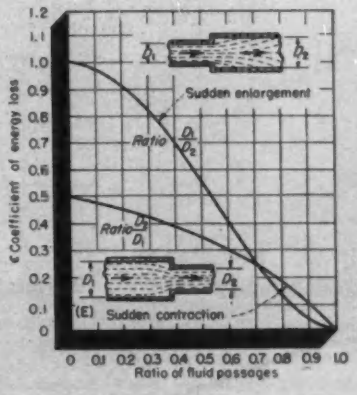
$G = 29.843\ C_{D_2} \Sigma D_n^2 \sqrt{\frac{P_1 - P_2}{S}} \times \phi_2$ (13)

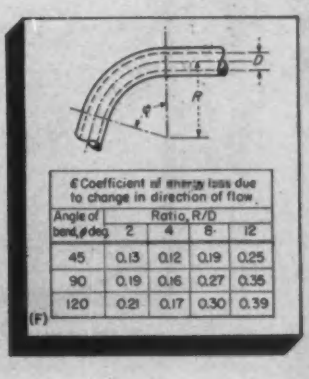
Where factor $\phi_2 = \frac{1}{\sqrt{1 - C_{D_2}^2 \frac{(\Sigma D_n^2)^2}{D^4}}}$ (13A)

and $\Sigma D_n^2 = D_1^2 + D_2^2 + D_3^2 + \cdots D_n^2$ (13B)

Special case:
When $\sqrt{\frac{\Sigma D_n^2}{D}} \leq 0.3$ (13C)
Factor $\phi_2 \rightarrow 1.0$ and can be neglected







€ Coefficient of energy loss due to change in direction of flow.

Angle of bend, ϕ deg.	Ratio, R/D 2	4	8	12
45	0.13	0.12	0.19	0.25
90	0.19	0.16	0.27	0.35
120	0.21	0.17	0.30	0.39

factor ϕ_1 is dependent on the velocity of approach and is graphically illustrated in Fig. 7. When the ratio of orifice to pipe diameter D_o/D is relatively large, this factor should be used, however for values of (D_o/D) about 0.3 or less, the ϕ_1 factor approaches unity and can be neglected. Under these conditions, Eq (9) is reduced to:

$$G = 29.843\, C_D\, D_o^2 \sqrt{\frac{p_1 - p_2}{S}} \qquad (10)$$

from this equation, the orifice diameter can be found:

$$D_o = 0.1831 \sqrt{\frac{G}{C_D}} \times \sqrt[4]{\frac{S}{p_1 - p_2}} \qquad (11)$$

or the coefficient of discharge:

$$C_D = 3.351 \times 10^{-2} \frac{G}{D_o^2} \times \sqrt{\frac{S}{p_1 - p_2}} \qquad (12)$$

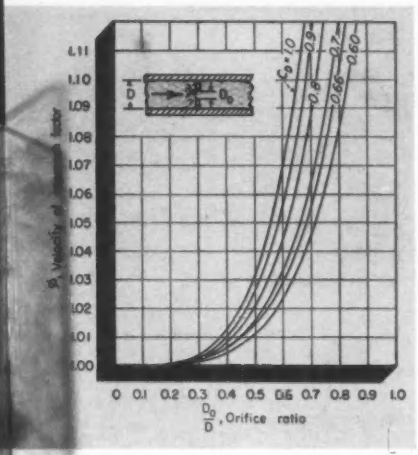


Fig. 7—Velocity of approach is affected by the orifice ratio; for small values of this ratio, velocity terms in energy equation are small and can be neglected.

Graphical Solution

In addition to piping losses, Fig. 4 can be useful in solving the rate of discharge from orifices. Fig. 8 illustrates how this chart is applied to orifice calculations and lists the necessary equations which are required.

Example 5: Find the rate of discharge of a fluid from a sharp-edged orifice with D_o of 0.593 in. in a pipe with D equal to 0.902 in. The pressure differential $(p_1 - p_2)$ is 19.6 psi and the coefficient of discharge C_D is 0.660. The fluid is AN-0-366 at 150 F and has a specific gravity S of 0.811.

Solution: Orifice to pipe diameter ratio D_o/D is 0.593/0.902 or 0.657. Due to the high value of this ratio, the velocity of approach factor ϕ_1 must be considered; from Fig. 7, ϕ_1 is found to equal 1.043. From Eq (9) the flow rate G =

$$29.843 \times 0.66 \times 0.593^2 \sqrt{\frac{19.6}{0.811}} \times 1.043$$

$$= 35.52 \text{ U. S. gpm}$$

Referring to Fig. 8, Line I is drawn parallel to Line A-A through point D_o = 0.593 in. The intersection of Line I and pressure differential $(p_1 - p_2)$ of 19.6, establishes the discharge rate G of 46.5 U. S. gpm. This chart value must be modified by Eq IV (Fig. 8) to find the actual discharge.

$$G_1 = \frac{46.5 \times 0.660}{\sqrt{0.811}} \times 1.043$$

$$= 35.5 \text{ U. S. gpm}$$

Divided Flow

Example 6: Find the discharge rate of an AN-0-366 fluid at 140 F through three thin-wall orifices of diameters: D_1 of 0.125 in., D_2 of 0.156 in. and D_3 of 0.187 in. The inside diameter of the tube D is 0.750 in. and the pressure differential $(p_1 - p_2)$ is 62.8 psi. The specific gravity is 0.814.

Solution: From Table I, Eq (13C) the ratio, $\frac{\sqrt{(\Sigma D_o^2)}}{D}$ =

$$\frac{\sqrt{0.125^2 + 0.156^2 + 0.187^2}}{0.750} = 0.36$$

Thus the velocity of approach factor ϕ_2 can be neglected in the flow equation due to the small value of this ratio. From Fig. 9 the coefficient of discharge C_{D2} can be chosen at about 0.650, and the discharge rate calculated from Eq (13) in Table I(D):

$$G = 29.843 \times 0.650\,(0.125^2 + 0.156^2 + 0.187^2) \sqrt{\frac{62.8}{0.814}}$$

$$= 12.77 \text{ U. S. gpm.}$$

Fig. 9 illustrates the close relationship between calculated and experimental results. The coefficients of discharge given on the graph should be useful for most cases, however, when great accuracy is required the specific coefficient should be experimentally found for each application.

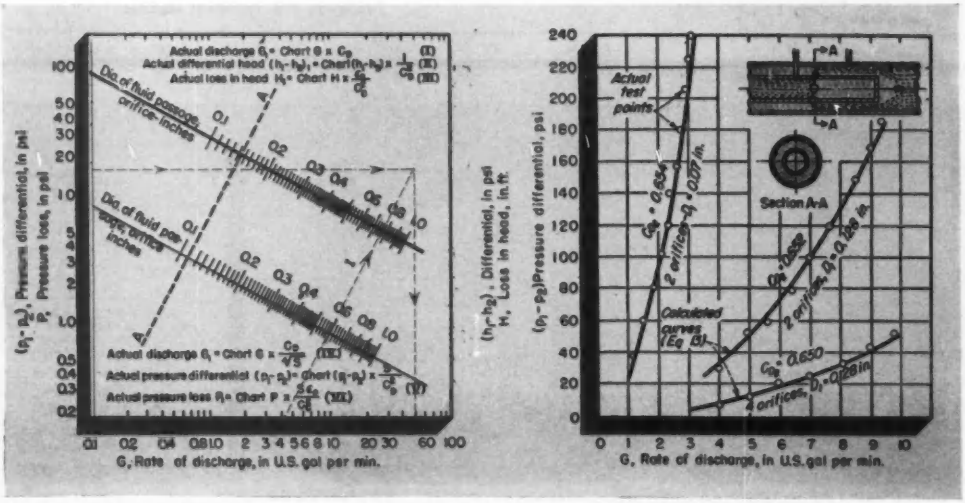

Actual discharge G_1 = Chart G x C_D (I)
Actual differential head $(h_1 - h_2)_1$ = Chart $(h_1 - h_2)$ x $\frac{1}{C_D^2}$ (II)
Actual loss in head H_1 = Chart H x $\frac{C_D}{C_D^2}$ (III)
Dia. of fluid passage, orifice, inches
Dia. of fluid passage, body, orifice, inches
Actual discharge G_1 = Chart G x $\frac{C_D}{C_D}$ = (IX)
Actual pressure differential $(p_1 - p_2)$ = Chart $(p_1 - p_2)$ x $\frac{C_D}{C_D^2}$ (V)
Actual pressure loss P_1 = Chart P x $\frac{C_D}{C_D^2}$ (VI)
$(p_1 - p_2)$, Pressure differential, in psi
P_1, Pressure loss, in psi
$(h_1 - h_2)_1$, Differential, in psi
H_1, Loss in head, in ft
G, Rate of discharge, in U.S. gal per min.
Actual test points
Section A-A
C_D = 0.650
2 orifices, D_1 = 0.177 in.
2 orifices, D_2 = 0.156 in.
2 orifices, D_3 = 0.128 in.
Calculated curves (Eq 13)
$(p_1 - p_2)$ Pressure differential, psi
G, Rate of discharge, in U.S. gal per min.

Fig. 8—For orifice problems, use the graph in Fig. 4 as shown above including the relations: Eqs I through VI.

Fig. 9—A comparison between calculated and test results of divided flow through orifices show good correlation.

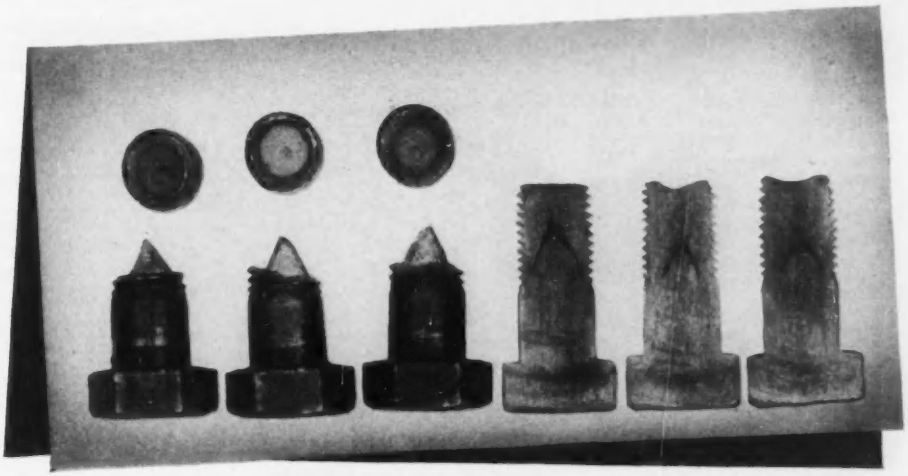


Fig. 1—Internal static tension fractures in bolts where the internal tensile stress induced by excessive rolling exceeded the static tensile strength of the core metal.

Fatigue Durability of Prestressed Screw Threads

Beneficial effect of superficial rolling on the fatigue durability of screw threads. Fatigue strength of screw threads before and after prestressing with rollers. Devices for superficially rolling threads and design of rollers.

J. O. ALMEN
Research Laboratories Division,
General Motors Corporation

WHEN BOLTS AND STUDS are of adequate length and are properly tightened against well designed abutments, their fatigue strength is not affected by the processes used in their manufacture. In an earlier paper (Ref. 1) it was shown that when proper tightness is achieved and maintained, bolts and studs experience negligible stress change regardless of the magnitude of changes in the working load. Under the foregoing conditions, since the bolt load is almost static, fatigue failures cannot occur.

All highly stressed bolts, however, are not properly tightened. Many bolts and studs are much too short. Washers, rough surfaces and soft metals dissipate initial tightness. And often little or no thought is given to the requirements of the bolted members. Under such adverse conditions, the processes used in forming the threads often become very important.

It is well known that under adverse conditions, notches, grooves, and other abrupt section changes can reduce the fatigue strength of machine parts by one half or more. Screw threads are serious fatigue hazards because the grooves greatly magnify the stresses from externally applied loads. It is important, therefore, to apply processes that will reduce the vulnerability of screw threads to fatigue failures.

Since fatigue failures result only from repeated tensile stresses (Refs. 2 and 3), and since the surfaces of structural metals are weaker in fatigue than sound sub-surface metal (Ref. 4), the vulnerability to fatigue failure may be decreased by reducing the tensile stress in a thin surface layer. This tensile stress can be reduced by inducing residual compressive stresses in surface areas that are subjected to repeated tensile stresses. After prestressing, the tensile stress in the relatively weak surface metal will be reduced by an amount equal to the residual compressive stress. In screw threads, the tensile stress from external loads is greatly magnified at the thread roots and the processing treatments should, therefore, seek to develop high magnitude residual compressive stresses in these areas.

Rolled Threads Stronger

The fatigue strength of screw threads formed by rolling is greater than that of threads produced by cut-

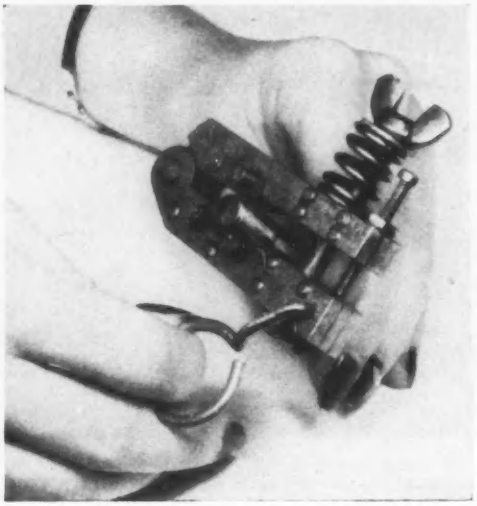


Fig. 2—Hand tool for superficial rolling of threads in small bolts and screws. Thread rollers are spaced approx. 120 deg apart.

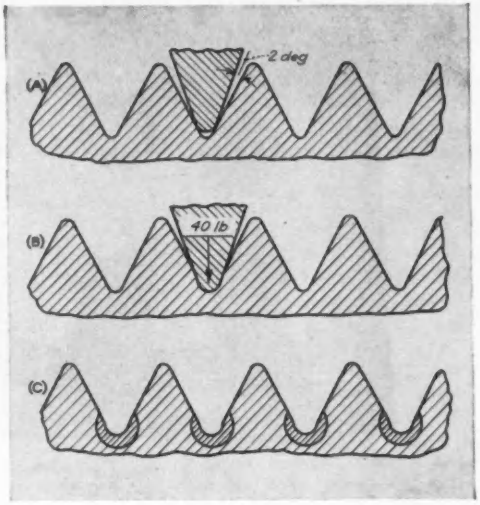


Fig. 3—Roller for superficially rolling screw threads is designed to stress the metal compressively at the root section of thread.

ting and grinding operations. Increased strength results from the residual compressive stress that is induced in the thread roots by the plastic deformation of the metal by the rolling dies. In these processes the surface metal is severely cold worked during depression of the grooves and elevation of the ridges. The surface metal is plastically and elastically extended to considerable depth in relation to the core. Upon removal from the dies, the elastically extended threaded section contracts to produce residual compressive stress to considerable depth.

Residual compressive stress in a surface layer requires residual tensile stress in the core to maintain force equilibrium within the specimen. The resultant tensile stress in the core, therefore, may become very great, since the tensile stress from tightening and the tensile stress from the external load are increased by the residual tensile stress. Because the fatigue strength of sub-surface metal is much greater than that of the surface metal, fatigue failures do not develop in the core. The net effect, therefore, is beneficial except where rolling is excessive or the material is of high hardness.

The internal tensile stress under extreme conditions may become greater than the static tensile strength of the core metal, in which event fractures of the type shown in Fig. 1 will develop. Under somewhat milder prestressing conditions, fractures originating internally will result from the sum of the residual tensile stress and the tensile stress for the tightening load or the applied load. These extreme cases are usually found in bolts in which the shank as well as the threads are formed by rolling steel of insufficient ductility.

The magnitude of the residual compressive stress that is developed by rolling at the thread roots varies with the static yield stress of the cold worked metal, consequently, the surface residual compressive stress as well as the residual tensile stress in the core increases as the hardness of the rolled material is increased. The greater the residual compressive stress at the roots of the thread the lower will be the resultant surface tensile stress from external loads. However, the harder the metal the greater will be the probability of internal fatigue rupture, particularly in the presence of sub-surface defects.

Screw threads formed by cutting and grinding operations are inferior in fatigue strength to rolled threads because the tensile stress concentrations at the roots of the threads are not offset by residual compressive stress. Also, in cut threads, the stress concentration in the critical areas may be further increased by rough and torn metal, and ground threads suffer from the added handicap of residual tensile stresses.

Prestress by Stretching

The fatigue vulnerability of cut and ground threads can be reduced by applying suitable treatments after the threads are formed. One such process is stretching the metal. A tensile load is applied to the stud or bolt great enough to exceed the elastic strength of the metal. Since the stress is greatest at the thread roots, local plastic yielding will occur in these areas. Upon release of the stretching tensile load, elastic contraction of the stretched metal will restore the threaded section to approximately its original length, whereupon the plastically extended metal at the thread roots will be residually stressed in compression.

The stretching operation can be performed during the tightening of the bolt by applying sufficient torque to exceed the elastic strength of the thread. The wrench is applied until the bolt is plastically extended a measurable amount. The effect is good whether or not the nut is subsequently backed off. If not backed off, the extra tightness reduces the stress range from the applied load. If the nut is backed off or if tightness is reduced during normal operation as by embedding of the bolt head, nut, or washer, the resultant residual compressive stress will serve to reduce the applied tensile stress.

Superficial Rolling

Another, and more controllable method of prestressing screw threads, is the application of a superficial rolling operation after the threads have been formed. Superficial rolling can be done with any simple roller shaped to a smaller angle than the standard screw thread and a somewhat greater radius than the root radius of the groove. The roller, or rollers, are

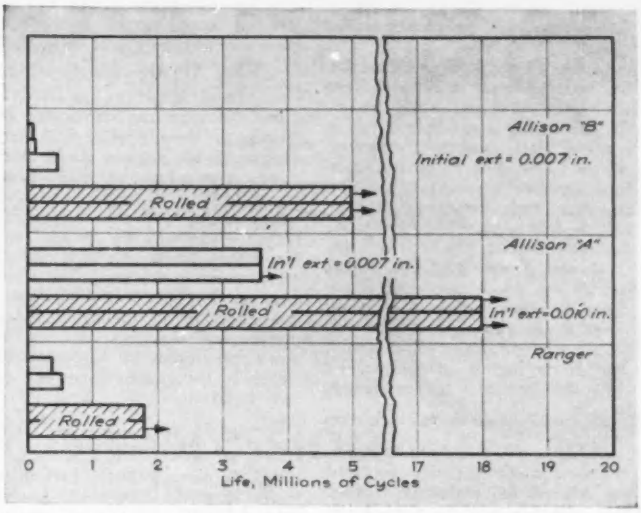


Fig. 4—Effect of superficial thread rolling on the fatigue durability of three series of bolts used in the connecting rods of the Allison and of the Ranger aircraft engines.

pressed against the root of the thread with sufficient force to plastically deform the metal in the vicinity of the root during relative rotation of the screw against the roller.

The roller tool may be a hand operated device, such as is shown in Fig. 2. This tool was constructed and used by the Research Laboratories Division of the General Motors Corporation during the late war for experimental rolling of screw threads. One hinged member of the tool is equipped with one roller and the other hinged member with two rollers. The rollers are ½in. dia and are spaced approximately 120 deg apart. The rollers are pressed into the thread grooves by a coil spring, which is loaded by a wing nut. A stop screw is provided whereby the device is prevented from collapsing when the bolt being treated is removed. The stop screw is adjusted to clear the opposite side of the hinge by approximately 1/64 in. when the device is in operation. The rollers have ample side and radial clearance to permit them to assume positions as required by the diameter and pitch of the thread to be rolled.

In Fig. 3 is shown the designed relationships of the thread groove and the roller tips. As shown in Fig. 3(A) the included angle of the roller tip is approximately five degrees less than the included angle of the grooves, and the roller tip radius is greater than the root radius of the groove, hence there is a clearance space between the roller and the thread root. Fig. 3(B) shows the roller after it is forced into contact with the thread root through pressure of the loading spring. The root metal as well as the metal on either side of the root is compressively stressed by this forcible engagement.

The desired residual compressive stress is developed only if the stress applied by the roller exceeds the elastic strength of the rolled metal. Residual stress magnitude and depth will vary with the magnitude and depth of plastic yielding. The shaded areas in Fig. 3(C) indicate, in a qualitative sense, the metal that should be residually stressed in compression. Fatigue strength increase will be greater as the magnitude of the surface residual compressive stress is increased but its depth is relatively unimportant.

Superficial Rolling Effects Tested

A number of fatigue durability test comparisons of screw threads rolled by the device shown in Fig. 2 have been made (Ref. 5). The results of some of these tests are presented in the bar chart, Fig. 4, which shows the relative fatigue durability of three series of bolts used in Allison and Ranger aircraft engine connecting rods. In each series, one group of bolts with threads as ground was tested; and for comparison another group having ground threads followed with superficial rolling was tested. The roller tip radii were 0.005 in., the included angle of each roller was 56 deg, and the load per roller was approximately 40 pounds.

Both series of Allison bolts were tested in connecting rods that were subjected to plus and minus 20,000 lb loads together with 1.5 deg twist in either direction. As indicated in the chart, these bolts were tightened sufficiently to elastically elongate the shank and the threaded section 0.007 and 0.010 in. in a total length of 2⅞ in. between the head and nut. Ranger engine bolts were tested in connecting rods that were loaded to 12,000 lb in tension and to 27,500 lb compression with no twisting. In all tests only the tension loads on the connecting rods were transmitted through the bolts. Initial tightness of the Ranger bolts was not measured.

No failure occurred in the Allison bolts that were superficially rolled, but one superficially rolled Ranger bolt failed after exceeding the durability of the non-rolled bolt by more than three to one.

The rolling tool shown in Fig. 5 is designed for use in a lathe. This tool has a 2½ in. dia roller journaled on the end of a 1¼ by ⅜ in. rectangular steel shank. The shank, which is sufficiently elastic to serve as a loading spring, is clamped in the tool post at an angle to position the roller axes substantially parallel to the screw thread to be rolled. The elastic constant of the shank is determined and the cross feed of the lathe may then be advanced the distance required to apply the desired roller load.

The bolt or other threaded member to be rolled is rotatably held by chuck

Fig. 5—Lathe tool for superficial rolling of coarse screw threads. The shank serves as a load control spring. Shank is set to keep roller axes parallel to screw thread.

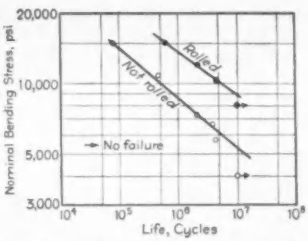


Fig. 6—Relative durability of superficially rolled and non-rolled screw threads.

or clamps, the longitudinal feed is adjusted to equal the thread pitch, the cross feed is advanced to load the roller and rolling proceeds by forward and reverse rotation of the work through the specified number of passes. The roller must have axial clearance on its journal to permit it to adjust its position as may be required to follow the thread without crowding.

Fatigue Durability Greatly Increased

Fatigue strength comparisons of screw threads before and after prestressing with the roller shown in Fig. 5 have not been made, but the effects of prestressing by a similar device are presented in the SN chart, Fig. 6. These data were obtained from tests on externally threaded steel ferrules used for attaching wooden propeller blades to their hubs. The tests were conducted by Wright Field (Ref. 6) under a loading schedule in which alternating bending stresses were superimposed on a constant tensile stress in an attempt to simulate the stresses occurring in service. It is seen that the prestressing increased the fatigue durability of the ferrules by more than 10 to 1. The ferrules being compared differed slightly in design, but this difference is not believed to have contributed to the change in fatigue strength of the superficially rolled threads.

In the Wright field tests the roller was loaded to apply an intended Hertz stress of 300,000 psi. Roller loading for prestressing is usually specified in terms of Hertz stress by the General Motors Corporation Research Laboratories Division. It is obvious, however, that such stress specifications can, at best, be only rough guides because the load must necessarily exceed the elastic strength of the metal. Well rolled threads will usually show visual evidence of plastic deformation of the metal at the thread roots, but only fatigue test comparisons will determine whether the load is sufficient to give the desired increase in fatigue strength.

Superficial Prestressing in Production

The superficial thread rolling devices described in the foregoing discussion are sufficient for small scale prestressing jobs, but they are obviously too slow for treatment of large quantities of bolts and studs. Slight modifications of normal thread rolling dies can be made whereby standard equipment will serve as well as superficial prestressing. Since the change in shape of the thread by the superficial treatment is small, no change from standard thread form need be made. If the thread before rolling is suitably modified, superficial rolling will then finish the thread to the standard form.

Superficial rolling on a commercial scale may be desirable in the production of bolts, screws and studs of high hardness. Forming of threads by conventional rolling processes in hard steel may be found too expensive and hazardous. Die maintenance and die replacement costs increase rapidly with hardness of the steel being rolled and greater difficulty is experienced in meeting dimensional specifications. Residual tensile stresses in the core metal increases the risk of sub-surface fatigue fractures.

PRESTRESS AFTER HEAT-TREATMENT. These difficulties can be avoided by forming the threads before final heat-treatment, when the steel can be more easily cut or rolled. After heat-treating to the desired hardness, superficial rolling can be applied to increase the fatigue strength of the threaded section without developing high residual tensile stress in the core. The treatment can be applied with similar beneficial effects to cut, ground, or rolled threads, but care must be used to assure prestressing of the threaded section to the extreme inner end of each thread.

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Sounds You Can See But Not Hear

HIGH FREQUENCY SOUND WAVES, sound waves beyond the range of your hearing, are proving to be a useful tool for research and for industry. Scientists find them useful for mixing such naturally insoluble substances as oil and water, or mercury and water. Industrialists find them useful for nondestructive testing of metal castings, and concrete structures; and for mixing paint pigments. Scientists see a future for ultrasonics for improving clothes washers, for agglomerating smoke particles, for pasteurizing milk, for sterilizing containers, and for many other uses. Scientists at the Westinghouse Research Laboratories are making a study of the fundamental properties of these waves.

The source of these waves is an unltrasonic generator. A jar of oil on top of the generator contains the heart of the device; a tiny quartz crystal. The application of an electronically generated, high electrical voltage across the crystal causes it to vibrate 750 hundred thousand times a second. These vibrations create ultrasonic waves; the ultrasonic waves agitate the molecules in the liquid and, if continued long enough, complete mixing or emulsification takes place.

The process can be recorded with a camera if test tube filled with water and mercury is immersed in the oil-filled jar a few inches from the crystal. As the impact of the sound waves takes effect, a cloud of minute particles of mercury forms in the water. Internal pressure is sufficient to blow the cork out of the test tube during the mixing process.

To make the sound wave pictures the room is darkened and light from a monochromatic source is beamed through a piece of ground glass. Time exposures of the film up to one minute are needed.

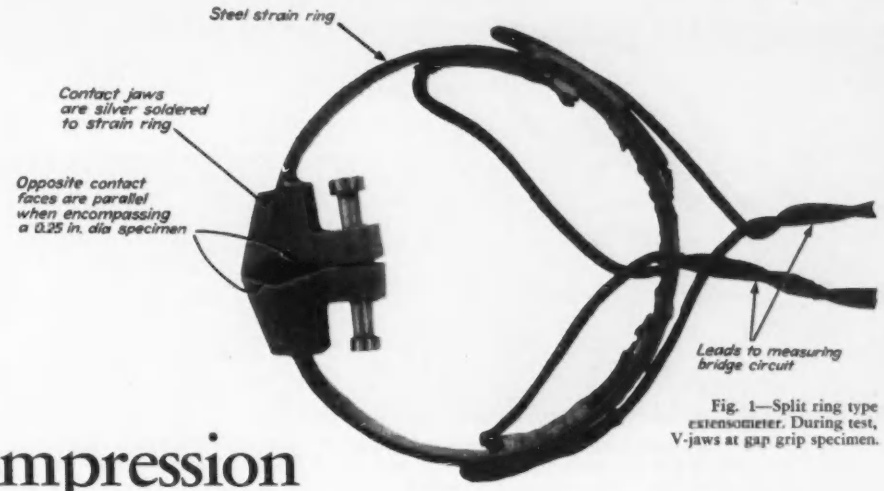

Steel strain ring
Contact jaws are silver soldered to strain ring
Opposite contact faces are parallel when encompassing a 0.25 in. dia specimen
Leads to measuring bridge circuit

Fig. 1—Split ring type extensometer. During test, V-jaws at gap grip specimen.

Compression Test Extensometer For Cylindrical Specimens

Development of an instrument for obtaining accurate stress-strain data when testing cylindrical specimens in compression. Extensometer can be used for ferrous and nonferrous materials at temperatures ranging from —70 F to 400 F. Operator safety may be assured by remote operation of tests.

A. M. STOTT, MECHANICAL ENGINEER, AND J. M. McCAUGHEY, PHYSICIST
Pitman-Dunn Laboratory, Frankford Arsenal*

DURING THE LAST THREE YEARS, the personnel associated with research at the Pitman-Dunn Laboratory at Frankford Arsenal have been engaged in a program for developing a method by which true stress-strain data as applied to compression testing can be obtained. Since published data on compression testing are limited and the commercial extensometers available were not suitable for this particular project, it was necessary to include in the program not only the planning of a test method, but also the design and construction of required instrumentation.

In studying several somewhat adaptable methods by means of which instantaneous dimensions could be obtained for known loading, the method used by Cook and Larke (Ref. 1) was considered. This method consists of obtaining measurements by means of a micrometer mounted directly across the platens of the die set used to compress the specimen. As the various loads are applied, the change in specimen length is obtained from the micrometer readings. The research programs at the Pitman-Dunn Laboratory required specially designed equipment of a different nature for two important reasons:

(1) Some materials to be tested were heat-treated steels of high hardnesses, some of which do not fracture until a stress of 600,000 psi is reached. Obviously, the complete protection afforded by remote operation would be desirable.

(2) The method considered most promising required measurement of the specimen's diameter instead of its length, for it was desired to determine the stress distribution in barreled compression test specimens in a manner similar to that employed by Bridgeman (Ref. 2), and also by Davidenkov and Spiridonova (Ref. 3) in obtaining the stress distribution throughout the neck of a tensile specimen as described (Ref. 4) by Read, Markus and McCaughey.

To satisfy these requirements, an electro strain extensometer capable of

* *The data presented in this article are those of the authors and are not to be construed as official data released by the United States Department of the Army.*

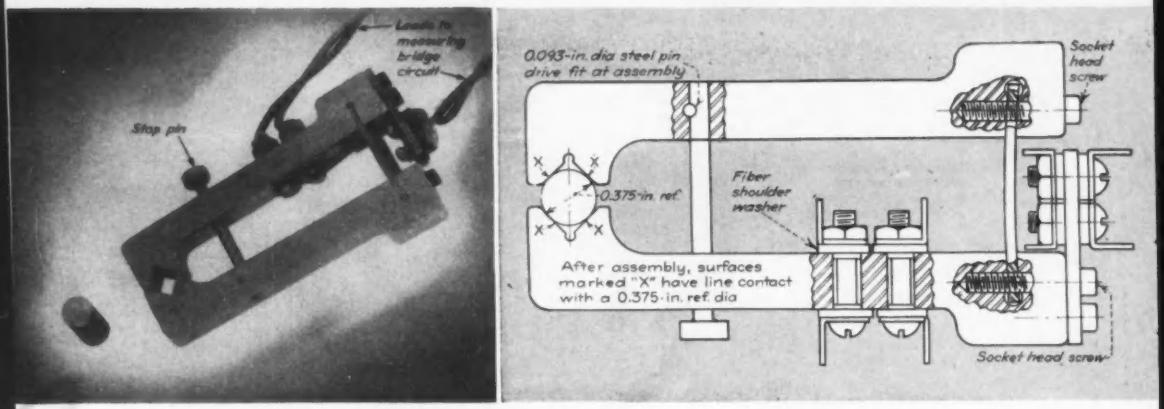

Leads to measuring bridge circuit
Stop pin
0.093-in. dia steel pin drive fit at assembly
Socket head screw
0.375-in. ref
Fiber shoulder washer
After assembly, surfaces marked "X" have line contact with a 0.375-in. ref dia
Socket head screw

Fig. 2—Improved extensometer for compression testing 0.375 in. dia specimens. Thin spring strain member is initially straight. Bend caused by angle of slots preloads jaws for clamping action.

measuring diameter changes was considered to be the most suitable type instrument. SR-4 wire resistance strain gages were selected for use in the extensometer, because they are sensitive and may be made to indicate small deflections to an operator at a remote station.

During the experiments several types of extensometers were used, and their mechanical designs changed to provide for the best use of the SR-4 wire strain gages.

The first extensometer was a circular split ring, which resembled a piston ring, to which two V-jaws were fastened at the split or gap as shown in Fig. 1. Three A-7 type gages were mounted around the inside surface and three more around the outside surface of the ring. Electrical connections were then made so that each set of three gages was in a different arm of the measuring bridge circuit.

Sensitivity Doubled by Mounting Gages Back to Back

With the gages mounted back to back, temperature changes were automatically compensated for; and the sensitivity essentially doubled, because the outside gages operate in compression whereas those inside operate in tension. When calibrated, this extensometer was found to have a calibration factor of one strain indicator division for each 0.00015 in. of movement of the V-jaws.

As established by the electrical circuit, one strain indicator division indicated a gage strain of one micro in. per in. of gage length or 0.0001 percent. Since the sensitivity of this unit is doubled by the back to back application of gages, a jaw movement of 0.00015 in. produces a strain in the gages that is indicated by the equivalent average of a half division, or a strain of 0.5×10^{-6} in. per in. of gage length. Hence, the relative movement of jaws as compared to the unit elongation of gages is 300 to 1, or 3.00 in. movement of the jaws for a unit strain at the gages averaging 0.01 in. or 1 percent.

Since the design of the ring section was based on a specimen diameter range of 0.375 to 0.475 in., or an increase in diameter of 0.1 in., the average maximum strain for the SR-4 gages is

$$\frac{0.1 \times 0.5 \times 10^{-6}}{0.00015} = 333 \times 10^{-6} \text{ in. per in. of gage length}$$

or approximately 0.03 percent. Since this strain is so low in value as compared to that permissible for this type of gage, any errors caused by fatigue or hysteresis should be negligible.

Even though comparatively good results were obtained with this circular

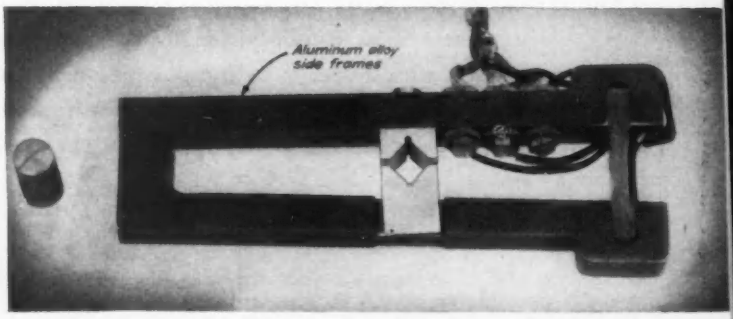


Fig. 3—Extensometer with plastic strain member for 0.375 in. dia specimens.

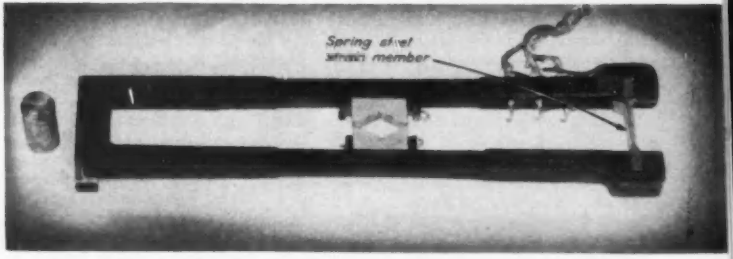


Fig 4—Extensometer for 0.5 in. dia specimens. Strain member is spring steel.

type extensometer in tests on a number of hard steels, additional study and experience indicated that it would be desirable to have:

1. Concentration of strain, caused by jaw movement, entirely in the strain member.
2. More clamping load on the jaws for improved gage alignment and for increased gripping force.
3. Uniform bending moment—resulting in uniform strain—in the strain member to which the SR-4 gages are attached.
4. Rigidly mounted binding posts for the attachment of the strain indicator leads in a way that prevents movement of the sensitive gage leads.

For these reasons, the extensometer shown in Fig. 2 was designed and built. A thin pre-loaded spring strain member is fixed slightly angularly in the relatively heavy side frames spanning the space between them, thus making the extensometer resemble a U-shaped pair of tongs.

In this instrument, the strain member acts as a beam, loaded only with equal bending moments applied at its ends. The bending moment and the strain, therefore, are constant across the span of the member. Inasmuch as the neutral axis of this member does not shift appreciably and is located midway between the gage surfaces, any increase in the jaw opening strains the gages an equal amount, one side in tension and the other side in compression. Working with a strain that is uniform along the length of the strain member, it was possible to use either AD-7 or ABD-7 SR-4 strain gages more effectively, which in turn resulted in increased accuracy of measurement of the jaw movement.

The calibration factor for this extensometer is one strain indicator division for each 0.00003 in. movement of the jaws. Hence, the ratio of jaw movement to unit gage strain is 60 to 1, that is 0.6 in. movement of the jaws for a unit strain of 0.01 in. or 1 percent on the SR-4 gages. No sacrifice in life of the strain gages was made in accomplishing this improvement, since the maximum strain on the gage over the range for which it was designed is 0.16 percent, a very low working value.

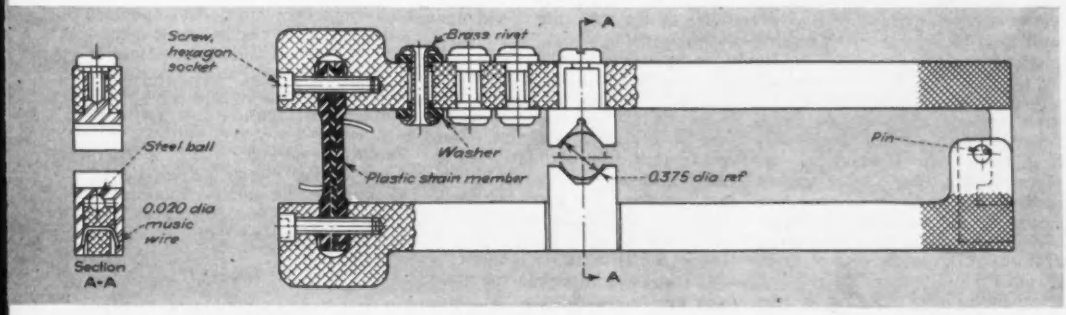
Tests on 0.375 in. dia steel specimens at various temperatures ranging from —70 to +400 F have been made using the improved type extensometer with remarkable ease and success. At low temperatures, the AD-7 type gages operated better than the ABD-7 gages and were therefore used in tests that were carried down to —70 F; but because of the limitations of the AD-7 gages, ABD-7 gages were used in tests that were carried up to +400 F. At room temperature, either gage is satisfactory.

By modifying the design slightly, but retaining the basic features of the improved type extensometer, further advancement was made in two later extensometers, Figs. 3 and 4. Since these were designed primarily to test 0.375 and 0.500 in. dia nonferrous specimens, the instruments were required to have greater operating ranges. Several design considerations are associated with this increase of jaw travel, since it is not only a function of the length of the side frame but is also dependent upon the configuration and properties of the strain member. The three most practical means of increasing jaw opening were to revise the design as follows:

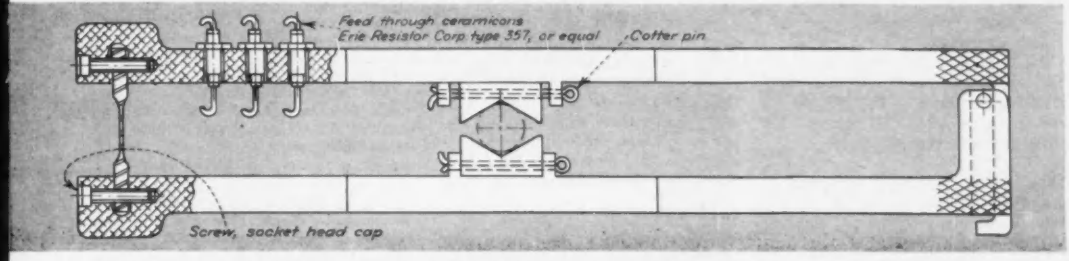
1. Increase the length of side frames.
2. Increase the length of the strain member.
3. Increase both the length of side frames and of the strain member.

After some deliberation, it was decided to use the last or combined method. Problems of weight and balance were presented with the increase of the side frame length. An aluminum alloy, therefore, was selected for the side frames, and the stop arrangement was redesigned to provide better balance for the instrument.

In this design, the jaws were mounted about midway on the length of the side frames. Also, the jaws were made self-aligning and detachable for easy replacement. Experience had



Strain gages are imbedded in sandwich fashion between the center and each outside layer of plastic strain member.



Center portion of steel strain member is reduced in thickness over a span just long enough to receive strain gages.

shown that removable jaws are desirable, since many of the harder specimens inadvertently had fractured under load scarring the integral type jaws to such an extent that re-machining was necessary.

The unique feature of the extensometer shown in Fig. 3 is the plastic strain member. This member consists of three layers of Plexene, which has a modulus of elasticity of 500,000 psi, having SR-4 gages imbedded sandwich fashion between the center and each of the outside layers.

This plastic strain member was constructed as follows. Gage lead holes were drilled in the outside pieces. Then the surface of the center piece were coated with solvent, the gages placed in position, and the outside layers attached. Heat and pressure were then applied to form a permanent bond between the plastic layers.

A portion of the excess solvent sealed the lead holes, thus waterproofing the strain member. The laminated plastic strain member was made thick enough to provide the force needed to clamp the jaws on the specimens. The SR-4 gages, however, being close to the plane of the neutral axis were held to a safe working range. Although this extensometer is still operating, manufacturing difficulty has been experienced when bonding other strain members of this type.

To avoid this manufacturing difficulty when designing the extensometer shown in Fig. 4, spring steel was again used for the strain member. The proper design was achieved by changing the moment of inertia of only the center portion of the span of the strain member. This center portion is reduced in thickness over a length only long enough to accommodate the gages. Hence, the strain member bends over a smaller radius and to a greater degree than would a member having uniform thickness throughout its length. The concentration of strain produced is sufficient for the required sensitivity. Proper selection of the center thickness and length of this strain member completely eliminated the need of a material of low modulus of elasticity. No other design difficulties were encountered.

The extensometer shown in Fig. 4 has been used successfully on many different materials. Its latitude of use is far greater than that of the other extensometers described.

CALIBRATION. The main advantage of the extensometers described is that they can be easily calibrated; this operation can be performed on each specimen as it is tested.

The method of calibration is the same for each of the extensometers described. The initial diameter of the specimen is carefully measured with a micrometer. The specimen is then gripped in the jaws of the extensometer and the initial strain indicator reading is observed for the unstrained specimen. (When a balancing bridge is used, this initial strain indicator reading can be adjusted to read zero.) When the test is completed the final strain indicator reading is noted with the load removed. The extensometer is then removed and a final micrometer measurement of the specimen diameter is made. The calibration factor is then determined by dividing the difference in the micrometer measurements by the difference in the strain indicator readings.

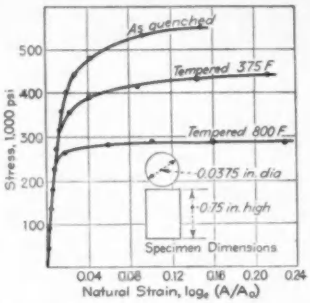


Fig. 5—True stress-natural strain curves for a heat-treated 0.70 C alloy steel. Natural strain is natural logarithm of ratio of instantaneous area to initial area.

In practice because of the stability of the instrument, these extensometers need only be calibrated once, after which the calibration factor can be used in all subsequent tests. Since calibration is easily performed and accidental damage may occur between tests, however, it is good practice to include the calibration steps in each run. Another important advantage is that a calibration factor obtained by this method may be used for the entire range of the instrument.

Extensometers of this general design have good linearity as has been proven by the straight lines obtained in numerous graphs showing diameter change of specimens plotted against strain indicator readings. Since the flexural moment varies directly with the force applied at the gage jaws, and the jaw force varies directly with jaw movement, and the SR-4 gages are linear, it follows that the calibration curve should likewise be linear.

TEST PROCEDURE. Tests that are to include a calibration start by measuring the specimen diameter with a micrometer. Then the extensometer is positioned on the specimen, and a reading of the strain indicator taken or the bridge circuit is adjusted until the strain indicator reads zero. With these initial readings recorded, the load is applied; and at predetermined load increments, the corresponding strain indicator readings are taken. By continually balancing the circuit so that the galvanometer needle always reads zero, accurate readings can be obtained when the desired loads are reached. After strain indicator readings are obtained for all the desired loading conditions, all the load is released. A strain indicator reading is then taken at no load, after which the extensometer is removed. The run is then completed by measuring the specimen diameter with a micrometer to obtain the permanent set of the specimen.

The increase of diameter corresponding to the various loads is obtained by multiplying the respective strain indicator readings by the calibration factor.

Tests were made with these extensometers to obtain true stress-natural strain curves for a variety of ferrous and nonferrous materials as a function of heat-treatment, grain size, and other metallurgical variables. In Fig. 5 one set of these curves is shown.

With these extensometers, valuable data not heretofore available have been obtained easily and accurately. These instruments permit a wide latitude in the selection of test material and temperature range. Also, operator safety may be assured by remote operation of tests. If a suitable automatic recorder is available, no personnel will be required for recording strain data during the test runs.

ACKNOWLEDGMENT. The authors thank C. Walt Musser, Technical Advisor at the Pitman-Dunn Laboratory, for his advice and guidance in designing the extensometers.

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TECHNICAL NEWS

Water Makers For the Army

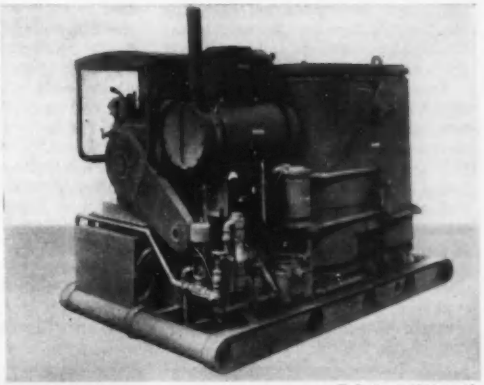
FT. BELVOIR—Global warfare has forced man to live in areas completely devoid of fresh water. In the arctic he must melt snow and ice. On some islands of the Pacific and in other parts of the world, he must obtain drinking water from the sea. One of the major fields of research conducted by the Engineer Research and Development Laboratories, is the task of developing equipment to provide an adequate supply of water to our troops wherever they may be.

Equipment used in World War II for the distillation of sea water produced up to 250 lb of water per lb of fuel. But scale from salts of the sea water formed on the tubes of the evaporator. This necessitated frequent shutdowns for removal of the scale and reduced the efficiency of operation by 50 percent. Studies by the University of California showed that if ample surface could be provided exterior to the evaporator, the amount of scale formed in the evaporator would be greatly reduced.

This method of scale control is now under test. The contact stabilizer being used consists of a metal shell containing sand, limestone or some other contact material through which brine from the evaporator is circulated by upward flow at a rate many times that of the sea water feed entering the evaporator. By providing such a larger surface of contact material the greater part of the scale is deposited in the stabilizer. Recent tests have revealed that the amount of scale formed in the evaporator was only 5 percent of that normally formed without scale control.

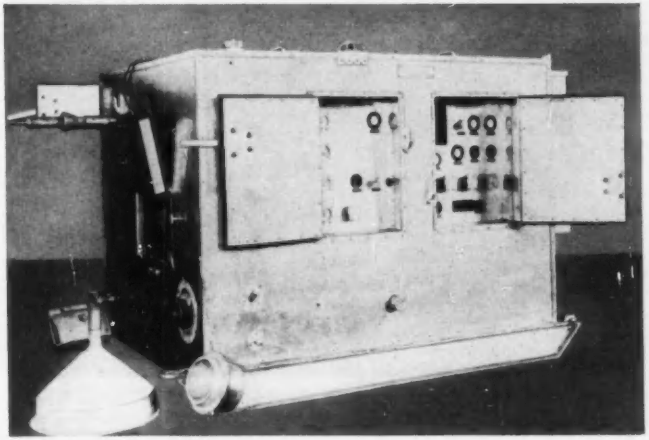
A garrison type thermocompression distillation unit, electrically powered and incorporating the scale prevention principle is currently being service-tested in Bermuda. Rated at 1,250 gph, this unit will make it possible to support readily a sizeable field force in an area devoid of fresh water sources. The unit weighs 80,000 lb and knocks down for shipment into loads not exceeding 15,000 lb. It has been designed to run about 3,000 hr or 6 months without stopping for scale removal as against the 700 hr period of conventional distillation units.

As to the other "area" problem, water supply in the Arctic, a steam generator type ice and snow melter is under development. Rated at 200 ghp, this unit is designed for operation under Arctic field conditions. It can be transported as a skid-mounted load on standard military vehicles.



THERMO-COMPRESSION DISTILLATION UNIT used by the Army in World War II to obtain drinking water from the sea. New units have greater capacity—1,250 gph as against 300 gph, and run longer without shutdown—3,000 hr. as against 700 hours. Some idea of the vastness of the water supply problem may be gained from the estimate that military needs for water run anywhere from 5 gal per day per man on a temporary bivouac to 150 gal per bed for hospitals. Adequate supply in tropical islands or Arctic regions is the most difficult.

—*U. S. Army Photograph*



ICE AND SNOW MELTER for use in Arctic regions. Developed by the Army Research and Development Laboratories at Ft. Belvoir, Va., it is rated at 200 gph capacity. Technical tests reveal that this equipment has many potential uses, including jetting on ice and frozen soil. It is but one of many specialized types of "back-up" equipment that is continuously being researched by all branches of the armed forces.

Background on "DO" Priorities

WASHINGTON—Since the DO made its bow as NPA Regulations 2 it has been under fire, first from industry, then from the armed services. Industry complained because the regulation initially assigned priorities only to military production and closely allied projects like the atomic energy program.

The military itself disliked the DO system, even though they could use it at their own discretion for most procurement items, because they had to share it. It was obvious that more production than that for the armed services would require priority assistance eventually. And the services didn't want anyone else using a DO equal to the military rating.

Basically, these complaints were aimed at the same thing: the underlying philosophy of the DO system. In the language of the bureaucrats, it's a "single band" system; that is, every DO has precisely the same status.

Whether issued by the Army or any other authorized agency, a DO calls for delivery of materials within a specified "lead time"—which varies for different materials. You can't set aside a DO-rated order for locomotive parts, for example, to take on a rated order for more urgently needed medium tanks.

The only alternative system—short of the broad allocation of materials you get with CMP—is a "multiple band" priority. This might consist, for example, of "A" priorities for military production, "B" priorities for essential civilian output, and, perhaps "C" priorities for components required by both. But it wouldn't take long for such system to bog down.

The DO's were conceived with the knowledge that more priorities would not get all the essential military and civilian production required by an all-

Big Squeeze Applied to Airplane Propellers Cuts

THE PROPELLER DIVISION of the Curtiss-Wright Corporation, Caldwell, N. J. has developed, in cooperation with the U. S. Air Force, a new mass production method of hot extruding one-piece, hollow-steel propeller blades for highspeed combat and commercial aircraft.

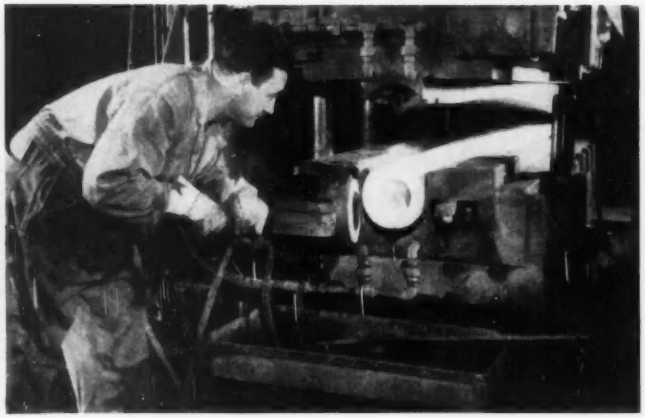
Regarded as a vital contribution to the National Defense program, the new extrusion process makes possible spectacular savings in strategic materials, skilled manpower, machining operations, manufacturing floor space, and tools. Operations in propeller manufacture, which now require hours of tedious hand work, are reduced by the new methods to a series of three steps which can be accomplished in minutes.

Improved producibility of the extruded blade is accompanied by a marked increase in blade quality and strength-weight ratio. The tough, homogeneous structure of the extruded steel provides geater resistance to the severe stresses to which propellers for higher horsepower piston and turboprop engines, now in production or being designed, will be subjected. The extruded blade has progressed well beyond the experimental stage. Production for U. S. Air Force aircraft already has been initiated and plans are being made to supplement welded types now being manufactured with extruded blades as facilities become available.

The successful development of the extruded propeller blade is the outgrowth of a research program undertaken by Curtiss-Wright under the sponsorship of the Manufacturing Methods Branch of the Industrial Planning Division and the Propeller Laboratory of the Engineering Division, Air Materiel Command, at the Air Force Development Center, Adrian, Michigan. While extrusion has been practiced by industry for over a quarter of a century, use of the basic process has been confined principally to the production of pipe, tubes, bars and other simplified forms except in the lighter and softer metals. When research program was inaugurated, no recorded data were available on the hot extrusion of steel in anything approaching the complex shapes and tapered thickness required in propeller blade manufacture.

From this start, Curtiss-Wright and Air Force technicians, with the aid of

FRANCIS R. O'LEARY, Curtiss-Wright Corporation, Caldwell, N. J., inspects a seamless, hollow-steel propeller.



EXTRUDED STEEL TUBE is transformed into a propeller blade by heating, flattening and forming against a die which gives it the proper twist and shape. Nitrogen, under 1100 psi pressure, provides internal support during this operation.

out mobilization effort. The idea was to get military production rolling while higher authorities decided how much we would need.

When it was apparent a CMP would be required, Defense Production Administrator Harrison and his aides became even more adamant against multiple-band ratings. It took WPB more than a year to get the numerous priorities already issued geared to the allocations and scheduling of CMP.

The DO's worked well as long as military contracts were going out at a slow rate. NPA kept the bulk of raw materials flowing in normal, non-military channels by authorizing materials producers to turn down DO's for more than a small percentage of their total output. But the DO ceilings went up, up—from 20 pc to 60 pc of output of some steel production, for example.

And the clamor for more priorities poured in from non-military producers. For a while, NPA broke some more serious bottlenecks—like the lack of components for electronics devices—by directives. The directives actually had the same force as DO's. In some cases, they carried even more urgency. They were the first break in the single-band system.

NPA next tried "certified programs." Railroad equipment makers, then production of ore boats got NPA certificates for the steel they needed for a limited number of items. The certificates were equivalent to DO's.

But the demands for critical materials was just beginning to boom. Use of the DO itself was extended to get civil aircraft and parts. Then it became obvious that nothing less would break the bottleneck in "MRO" (maintenance, repair and operating items).

The military had been getting MRO items through DO-98's, a special priority for the purpose. But the procedure for getting 98's was cumbersome, involving clearance with the purchasing agency for each item needed. And it didn't do civilian industry a bit of good.

There'll be DO's also—or their equivalent—for a number of civilian requirements. Before too long now that military orders are expanding, there'll be more DO's than there are materials.

At that point, look for the military to demand multiple-band priorities, with an overriding rating for all arms orders. And the first time a DO for a civilian type end item prevents or even slows the placement of an order for tanks, ships or guns, it's goodbye to the single priority.

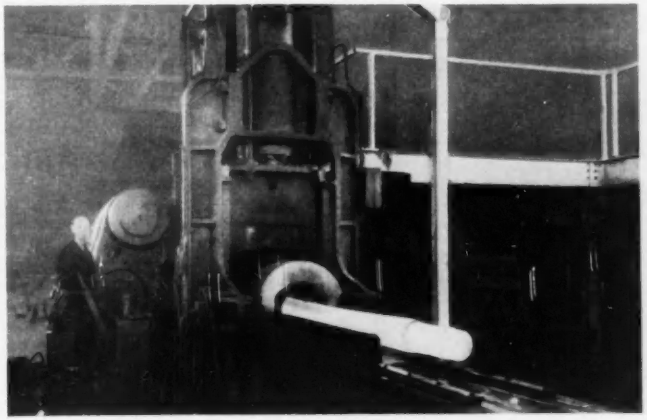
The mobilizers just hope it won't happen before CMP takes effect.

Production Time by Hours

the metal working industry, perfected in less than two years, the technique of squeezing a white-hot 400-pound chrome-nickle-molybdenum steel billet through appropriate dies with a 5,500-ton press to produce a 200 lb 10 ft propeller blade tube. This process, accomplished in three stages, contrasts with present time-consuming methods of welding together, brazing and forming two specially-processed flat plates, weighing 750 pounds before machining, to produce the same sized blade.

The rough propeller blade comes from the extrusion press in the form of a tapered-wall, seamless, round tube with "ears" or ridges running from the shank to the tip. In subsequent operations, the tube is flattened and shaped and the ears become the solid leading and trailing edges of the blade. Finishing operations are similar to those now used.

Application of the new process should reach beyond the aviation industry. On the basis of experience gained in the propeller blade development program, those who participated are of the opinion that the new methods have unlimited possibilities in other fields. Listed among items which can be produced by extrusion are landing gear struts, helicopter masts, helicopter main rotor blade spars, gun barrels, tank parts, ship parts, and members for prefabricated structures such as bridges and towers. Completed extruded blades are of the same hollow-steel monocoque design as welded blades. Essentially rectangular in shape, they are widest at the tip.



SHANK END FIRST, a white-hot propeller blade tube emerges from the press on the third and final extrusion. The process reduces to minutes operations in propeller manufacture which previously took hours to complete.

Aid for Aging Prospectors

WASHINGTON—A request for $10,000,000 government money to stimulate exploration for scarce minerals seemed to have cleared its biggest hurdles last month. Details of a program were worked out by James Boyd, Defense Minerals Administrator, and approved by E. T. Gibson, Deputy Administrator, Defense Production Administration. Once the money is formally allocated for the purpose by W. H. Harrison, DPA administrator, all that will stand in the way of action in the field will be the rules governing applications for aid. These will be drawn up by Defense Minerals Administration.

The program, as approved by Secretary of Interior Oscar Chapman, empowers the government to enter into exploration contracts on a project by project basis. In general, prospectors must match government money on a 50-50 basis. In case the mineral is particularly scarce, the matching formula may vary, with the government putting up a greater share.

If the applicant for aid earns any

profits as a result of the exploration, he will repay an amount to be fixed by the Secretary of Interior from net mill, smelter or other proceeds. The contracts will call for monthly reports on progress and field checks will be made by engineers and geologists for the government.

The administration of the plan will be in the hands of the Defense Minerals Administration. Here are the metals and minerals included in the exploration agreement: manganese, chrome, cobalt, nickel, tungsten, molybdenum, fluorspar, miscellaneous ferro-alloy ores, beryl, cerium and rare earth ores, columbium, lithium, platinum group (unrefined materials), tantalum, antimony, bismuth, copper, lead, mercury, zinc and cadmium, asbestos, cryolite, sulphur, kyonite and other mullite refractories, mica (strategic grade), monazite.

Prestressing Improves Fatigue Life of Aluminum

THE LIFE OF ALUMINUM ALLOYS that are subjected to vibration and other repeated or fluctuating stresses may be materially affected by applying stress to the material before it is placed in operation. Recent investigations at the National Bureau of Standards have shown that prestressing, in some instances substantially increases the fatigue life. This was especially noticeable at lower stresses when a comparatively small number of cycles of dynamic prestress were applied. On the other hand, there were cases in which little if any improvement resulted and at some stresses the fatigue life was shortened by the prestress.

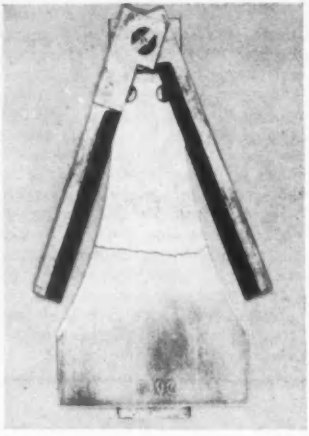


FIG. 1—FATIGUE-TEST SPECIMEN of aluminum alloy in special measuring jig. Although conventional repeated-bending fatigue-testing machines were used, the design of the specimen was new (illustrated). A special jig locates point of maximum before testing.

One of the difficulties encountered in applying results of laboratory tests to practical construction arises from the fact that, in many structures, the stresses vary in a random manner. An airplane wing, for example, must support not only the weight of the plane, which is a steady load, but also a fluctuating load due to vertical gusts. To approximate this situation, the cumulative effect of fatigue stressing at two or more different amplitudes was evaluated, using aluminum alloy sheet specimens.

Two means of prestressing were employed. In the first, a rather high static load was applied to the specimen before the start of the fatigue test. In the second, the specimen was stressed in the fatigue-testing machine for a predetermined number of cycles at one amplitude, and then carried to failure at a second amplitude.

Conventional repeated-bending fatigue-testing machines were employed. The design of the specimen, however, was new and was found to have several advantages over the usual type. Another innovation was a jig which measured the specimen before testing and automatically located the point at which the stress in the specimen would be a maximum. The accompanying illustration shows the specimen design.

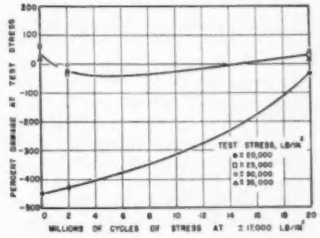


FIG. 2—EFFECT OF DYNAMIC PRESTRESSING at 17,000 psi on fatigue strength of 24S-2 aluminum-alloy sheet. Specimens were stressed at 17,000 pounds per square inch in the fatigue-testing machine for a given number of cycles (plotted along the abscissa) and were then carried to failure at another stress. The relative fatigue life of the prestressed specimens as compared to the original material is plotted as the ordinate. Negative values of the ordinate indicate that the prestressed specimens ran a greater number of cycles before failure than did specimens of the original material.

Pushbutton Weapons Still Under Wraps

Push-button warfare is still a long way off. The weapons of tomorrow are kept under wraps in the Defense Department's Research and Development Board. The Korean War and perhaps the entire next war, if it comes soon, will be fought with weapons and equipment designed and tested during World War II.

Since 1945 there have been only two new weapons in active combat. They are the 3.5 in. Bazooka and the 105 mm Recoilless Rifle. However, almost every piece of military equipment is undergoing some degree of change.

Reduction of weight is the keynote. During the last war, it took two men to carry a mortar. One hauled the weapon and the other, the base plate. The plate then in use weighed 48 lb and consisted of two sections for mobility. The base plate is now a one-piece titanium plate weighing about half as much.

The new 3.5 in. Bazooka is an outgrowth of the smaller 2.36 in. model of World War II. The weapon is simply a pipe, magneto actuated by trigger, and a safety device in the rear for the loader. The projectile carries the propellant and shaped charge. Design simplicity is apparent when you consider that the projectile can be fired without the pipe. The container for the projectile can be used as a one-time launcher, if necessary. However, accuracy is lost in doing so.

The Recoilless Rifle now comes in three bores. The 57 mm, weighing 44 lb, the 75 mm, weighing 105 lb and the 105 mm rifle, weighing 350 lb. The 105 mm is new in combat but like the 3.5 in. Bazooka, is an enlargement of its predecessors; it is now mounted on a jeep.

Mobility is the goal in artillery. The towed gun or howitzer is being replaced by self-propelled weapons. But even though self-propelled guns and howitzers have advantages of speed and mobility, they are meeting

opposition in the infantry. Opponents point out that when the carriage is knocked out, the gun is useless. Besides, larger self-propelled guns and howitzers run into difficulty on recoil with high elevation firing.

One of the biggest headaches during the last War was the lack of standardization in all services. Stock designations for identical parts looked like rows of phone numbers. This has been trimmed from 700-thousand to 300-thousand numbers in the Army's catalog and is still being cut. All military motor vehicles are now bought by the Army. This has cut red tape and resulted in uniform specifications to suppliers.

Trucks and jeeps are now being completely water-proofed. They are able to run partially submerged with air intake and exhaust pipes projecting above the surface. All units have 24-volt electrical systems for complete interchangeability with aircraft, signal corps, and field power units. Plans are in the mill for a single type truck, jeep and recon engine, differing only in hp capacity. Three sizes will be built. Engines will be completely air-cooled.

All construction equipment is being redesigned to allow for transportation by air. The tractor-dozer used by the Seabees and Airborne engineers now has a maximum allowable weight of 16,000 lb. Solid steel plate has been replaced by lighter webbed castings. Brush guards are lightened or removed entirely. Additional weight after air transport can be obtained by filling tanks (specifically added for this purpose) with wet sand.

Navy equipment is undergoing comparable changes. Present landing craft, ships' boats, minesweepers and related Navy gear are essentially of the same design as used in World War II. This is due to re-employment of mothballed equipment. However, new designs are in the construction stages.

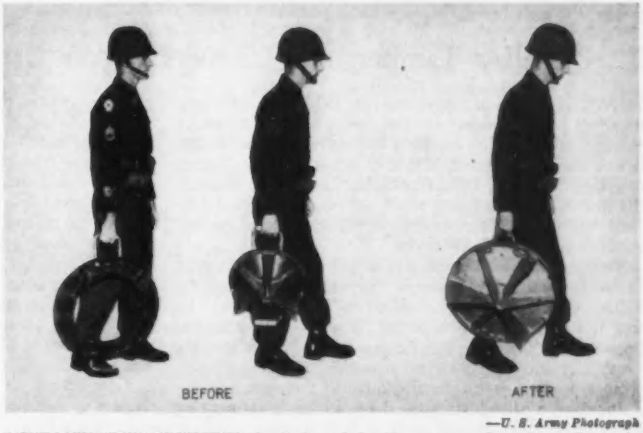
The Navy is working on development of a closed cycle power plant for submarines. The German-designed Walther engine utilizing hydrogen-peroxide as fuel was dropped. But German hull designs were retained. The double hulled sub with the living and working spaces in one hull and the power plant in the other is being adopted. Hulls are now able to withstand far greater pressures. Reduction in hull diameter is partially responsible for this improvement.

Submarine speed is greater. Latest subs are designed to fight entirely below the surface. Some are almost unseaworthy when surfacing in rough weather, due to the narrow beam.

Killer Submarine K-1, the Navy's

—*U. S. Army Photograph*

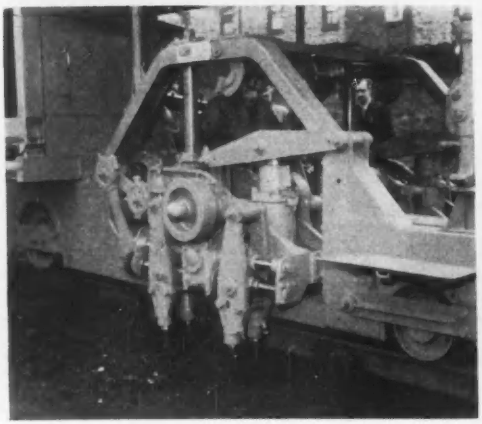
NEW WEAPON. This 3.5 in. bazooka and the 105 mm recoilless rifle are the only new U. S. weapons that have been developed and put into combat since 1945.



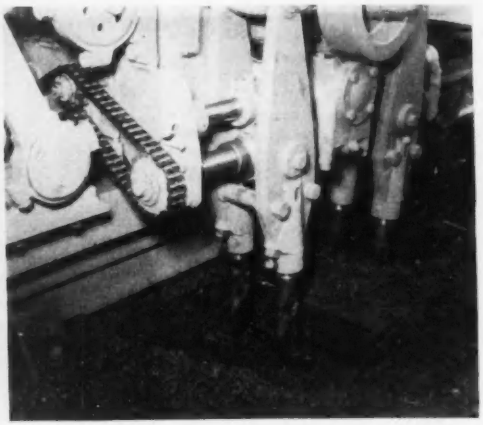
—*U. S. Army Photograph*

HOW TITANIUM SIMPLIFIES the design of the 81 mm motor baseplate. Formerly made of steel, the baseplate has to be constructed in two sections so that it could be handled in the field; total weight was 48 lb. The weight of the new unit: 24 lb.

AIRBORNE TRACTOR being driven into a Fairchild Packet plane. Tractor-dozers and other equipment is being redesigned for transportation by air.



THE TAMPING FRAME of the British built Matisa ballast tamper with tools lowered in the working position.



THE TAMPING TOOLS AND DRIVE SHAFT, which "closes the claws" of each pair of tools.

Ballast Tampers and Cleaners Spruce Up British Railroads

LONDON—First of an order for 25 Matisa automatic vibratory ballast tampers has just been placed in service by British Railways. The machine, originally of Swiss design, is now being built under license in Great Britain. Clayton Goodfellow & Co., Ltd., Blackburn, Lancashire, assemble the British-made machines, which are equipped with a Leyland 300 cu in. diesel engine in place of the American diesel fitted on the Swiss model.

The first machine delivered to British Railways has gone to work in the Peterborough district, consolidating the ballast of the main London-to-the-Northeast line. Its first job was on a stretch of the "down" (that is, northbound) fast line near the Flatton signal box, where the heavy clay subsoil has shown a marked tendency to subsidance, leading to uneven alignment of the track.

In place of hand-tamping, the machine is compacting about a half mile of track in about half an hour.

The Matisa tamper is a two-axle on-track machine which weighs 9¾ tons. It is equipped with eight pairs of chrome-manganese spade-headed tamping tools, mounted on two mobile frames, one on each side of the machine. These tools are so disposed that there are two pairs outside and two pairs inside each track rail; all eight pairs, when in action, are astride the same tie.

For tamping, the tools are lowered into the ballast, and afterwards raised clear, by moving the mobile frames up and down in their slides by means of compressed air. When the tools are in the ballast to the required depth, high frequency vibration is imparted to them by means of eccentrics, and at the same time each pair is drawn together towards the tie by the action of a driven shaft with right and left-handed threads. Power for these purposes is transmitted from the engine by a series of chain drives.

This makes the pairs of tools gradually closed, like gigantic claws. The ballast is thus packed beneath that portion of the tie that supports the rails. The ramming action continues until a pre-determined compression is reached; friction couplings then automatically release the action and the tools are raised ready to tackle the next tie.

The machine progresses from tie to tie by means of a simple pedal action. 600 to 700 ft of track can be ballasted per hour, while raising the track up to 2 in., with Matisa machine.

Compressed air for raising and lowering the mobile frames is supplied by a 15 hp Ingersoll-Rand two-stage compressor unit capable of providing 72 cfm at 11 atmospheres. A 25-gallon cylindrical air reservoir is mounted so as to constitute the central cross-member of the chassis.

An outstanding advantage of the Matisa tamper is that it does not have to block the line while in operation.

The Swiss Matisa concern also manufacture an automatic ballast cleaning machine which removes deteriorated ballast from the rail track, screens it, returns it to the track or deposits it alongside for future use, and discharges the waste screenings. Mr. G. S. Thurley, managing director of Matisa Equipment Ltd., states that he hopes soon to manufacture this machine in Great Britain, too, powered by a larger Leland diesel engine.

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answer to hostile subs, was launched at the Electric Boat Company in Groton, Conn. early in March. The new undersea craft is 195 feet long and displaces 750 tons which is only half the size of present fleet type subs. Adaptable to mass production, the K-1 boasts latest developments in sonar and other electronic gear.

The Navy also has under contract a gas turbine for electrical generation equipment to be used aboard minesweepers and sub-chasers.

The same tendency toward lighter weight and less bulk is exhibited in latest Air Force equipment. This, of course, is a continuing "must" for the Air Force. However, the Air Materials Command is constantly working to reduce weight and size of components already in use.

A typical example of recent design improvements is the Airborne turbine starter. The turbine, deriving its power from gas, weighs less than 18 lb. The starter is similar to a turbojet engine. But, instead of supplying available energy as a propulsion jet, this gas turbine supplies available energy as compressed air to start engines.

Cradle Bearings and Hydraulic Torque Measurement

DETROIT—Special journal-type cradle bearings are used on dynamometers to improve accuracy of measuring auto engine power output. This was reported recently by two General Motors Research Laboratories engineers, Warren H. Smith and Joseph B. Bidwell, before the Society of Automotive Engineers sectional meeting.

The special bearings described by the GM Research engineers consist of two semi-circular pads that support the dynamometer cradle. The dynamometer housing is cradled between two bearings. They are lubricated by a pressurized oil film so no metal-to-metal contact occurs. An external pump supplies the oil through recessed pads in the bearing surfaces.

The two main advantages of the new dynamometer bearing design are:

1. No friction occurs to cause errors in measuring engine torque, the rotary force or twist of an automotive engine shaft which is so important in determining the performance.

2. Fretting corrosion is eliminated.

A new hydraulic weighing system also is used for measuring torque in the improved dynamometer installations.

The new system measures engine torque by means of fluid pressure.

The main advantage of the hydraulic system in auto engine testing, is that it eliminates mechanical parts which eventually become inaccurate from wear. It also can be set up so that the torque reading indicator can be mounted at any convenient place on the dynamometer apparatus. This was not possible with mechanical scale measuring device formerly used.

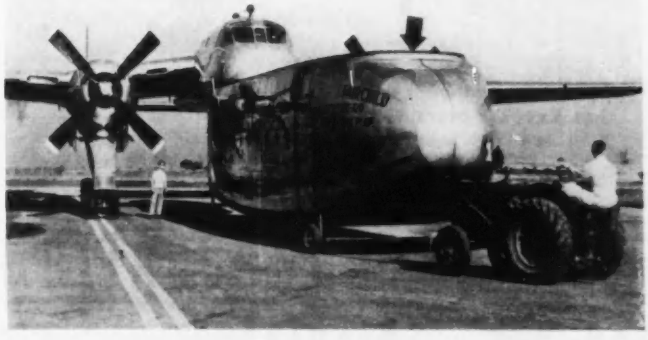
The cumulative effect of these improvements are particularly important in studies of automotive engine friction when the engine operates at road load under moderate speeds. Heretofore it has been difficult to obtain accurate measurements at such speeds, and this data is important in checking fuel economy and mechanical efficiency.

"Inner Tube" Seal for Packplane

THE SEAL THAT CLOSES the two inch space between the cargo pack and fuselage of the new Fairchild packplane actually is a 100 ft inner tube. Ordinary inflated seals and compression seals which first were tried put up a 3½ ton separating force on the plane and got damaged in positioning the pack for attachment.

Engineers of the B. F. Goodrich Company started with an inflatable tube made of rubberized fabric with a soft rubber base. They cured a special rubber strip to the top of this and thus formed a lip-type seal which was attached to the pack.

Deflated height of the tube, only ¾ inches, allows plenty of clearance during attachment to the pack. It inflates to 8½ times its deflated height, providing an airtight seal. Because contact with the plane is made by the soft rubber lip instead of the tube itself, there is separating force.



CHEMICALLY COMBINED silicone alkyd resins have been developed by the Plaskon Division of Libby-Owens-Ford Glass Company. Designated "Plaskon ST-856", "ST-873", and "ST-881" resins, they are expected to find many military and civilian uses because of their excellent resistance to heat, gasoline, oils and certain chemicals and atmospheres.

•

PLANS FOR A SURVEY to determine the research facilities and availability of personnel in over 1,000 American colleges and universities were announced recently by Dean Athelstan Spilhaus of the University of Minnesota, chairman of a sub-committee of the Engineering College Research Council. Copies of the survey will be supplied to the RDB and to all military agencies concerned with contracting for research services of educational institutions. The AEC, National Science Foundation, and other Federal and industrial groups will also receive the findings.

•

THE AMERICAN SOCIETY FOR METALS has arranged for detailed personal and technical background data for metallurgy and metallurgical engineering graduates of 44 Universities and Technical Institutions to be disseminated among its own members and some 5,000 industrial plants who might need such men.

•

GOVERNMENT SPECIFICATIONS of percentages of natural and synthetic rubber in many products took effect on April 1. However, the long range outlook is for "rubber running out of our ears". Reason: once stockpile is built up, the output of government-owned synthetic plants can take care of total U. S. needs—except for a small amount of natural rubber.

•

THE NEXT PRIVATE SEMINAR on the organization and operation of company standardization work will be conducted by Dr. John Gaillard of the American Standards Association from June 18 through 22, 1951. Interested persons may write to Dr. Gaillard at 400 West 118 Street, New York 27, N. Y.

•

SKID-DETECTING DEVICES now keep all B-47 and B-51 planes on the straight and narrow, no matter how hard pilots step on the brake pedals. The Air Force plan to equip other planes with the devices which have been used by railroads and may be suitable for

Now Available

NEW CLASS H*

MOTORS PROTECTED BY DOW CORNING SILICONES

. . . the insulation that has already saved industry millions of maintenance dollars plus the hourly output of hundreds of thousands of men!

This most timely announcement caps the test program we started 8 years ago when silicone resins were introduced by Dow Corning Corporation. First we proved by accelerated life testing that silicone insulated motors had a good 10 to 1 advantage in life expectancy and wet insulation resistance. Then we sold silicone (Class H) insulation to the manufacturers of electrical equipment ranging from lift truck and traction motors to solenoid and brake coils. We also encouraged the better rewind shops to rebuild hard working industrial motors with Class H insulation.

Now we can proudly refer American industry to this goodly list of electrical manufacturers, all able and willing to supply electric machines protected by Class H insulation made with Dow Corning Silicones.

Take your special problems to the application engineer representing any of these companies or to our Product Development Engineers.

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ELECTRIC CORPORATION

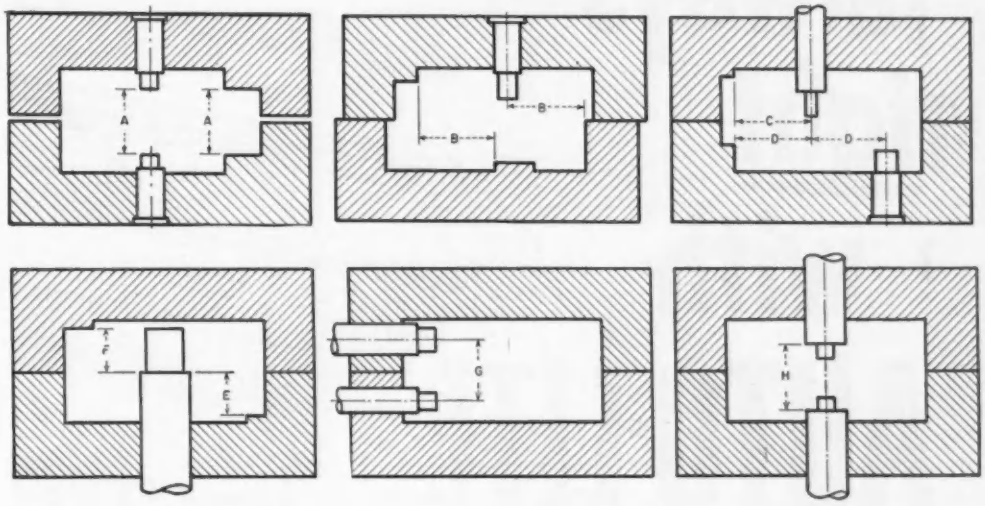
THE MASTER ELECTRIC COMPANY

* "Class H" insulation is the kind of insulation that keeps motors running in spite of "Hell and High water." *(language dictionary)*

DOW CORNING CORPORATION
DOW CORNING SILICONES
MIDLAND, MICHIGAN

Commercial Tolerances for Die Castings

H. K. BARTON



ALLOY GROUP		TIN	LEAD	ZINC	ALUMINUM	MAGNESIUM	COPPER
A—dimensions between fixed points in opposite die members, taken across the die parting	Basic variation	+0.003 −0.000	+0.003 −0.000	+0.004 −0.000	+0.006 −0.000	+0.006 −0.000	+0.009 −0.000
	Add for each inch of the dimension	±0.0003	±0.0003	±0.0005	±0.0008	±0.0008	±0.0015
B—dimensions between fixed points in opposite die members parallel to die parting.	Basic variation	±0.002	±0.002	±0.003	±0.004	±0.004	±0.006
	Add for each inch of dimension.	±0.0003	±0.0003	±0.0005	±0.0008	±0.0008	±0.0015
C & *D*—dimensions between a moving core and a fixed location in the same (*C*) or opposite (*D*) member at right angles to the core axis and parallel to the die parting.	Basic variation *C*	±0.001	±0.001	±0.0015	±0.002	±0.002	±0.004
	Basic variation *D*	±0.001	±0.004	±0.006	±0.008	±0.008	±0.10
	Add for each inch of dimension.	±0.0003	±0.0003	±0.0005	±0.0008	±0.0008	±0.0015
E & *F*—dimensions between a moving core and a fixed location in the same (E) or opposite (F) member parallel to the axis of die parting and core withdrawal.	Basic variation *E*	±0.001	±0.001	±0.0015	±0.002	±0.002	±0.004
	Basic variation *F*	+0.004 −0.001	+0.004 −0.001	+0.0055 −0.0015	+0.008 −0.002	+0.008 −0.002	+0.012 −0.004
	Add for each inch of dimension.	±0.0003	±0.0003	±0.0005	±0.0008	±0.0008	±0.0015
G—dimensions between centers of moving cores housed in opposite die members, taken at right angles to the die parting.	Basic variation.	+0.003 −0.001	+0.003 −0.001	+0.004 −0.002	+0.006 −0.003	+0.006 −0.002	+0.008 −0.003
	Add for each inch of dimension.	±0.0003	±0.0003	±0.0005	±0.0008	±0.0008	±0.0015
H—dimensions between locations on moving cores housed in opposite blocks, taken across the die parting.	Basic variation.	±0.004	±0.004	±0.006	±0.008	±0.008	±0.010
	Add for each inch of the dimension.	±0.0003	±0.0003	±0.0005	±0.0008	±0.0008	±0.0015

(*continued on page* 171)

You're always right with AUTO-LITE

Industrial Wire & Cable

• The quality of Auto-Lite Wire and Cable is the result of nearly 40 years of experience, research and advanced laboratory tests. This, plus the tremendous output possible in Auto-Lite plants at Port Huron, Michigan and Hazelton, Pa., makes Auto-Lite a logical source of supply for wire to fit every need. Address inquiries to:

The Electric Auto-Lite Company
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Plastic Insulation—Special "B" Cotton Braid—"CA" Lacquer
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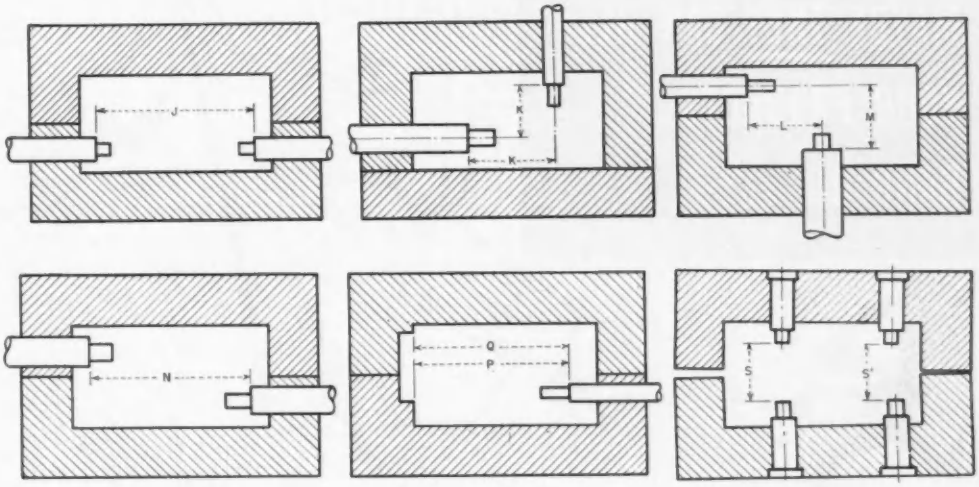
WIRE & CABLE • DIE CASTINGS • PLASTICS • INDUSTRIAL THERMOMETERS

Commercial Tolerances for Die Castings (continued)



ALLOY GROUP		TIN	LEAD	ZINC	ALUMINUM	MAGNESIUM	COPPER
J—dimensions between locations on opposed moving cores in the same die member.	Basic variation.	+0.006 −0.000	+0.006 −0.000	+0.008 −0.000	+0.010 −0.002	+0.010 −0.002	+0.014 −0.004
	Add for each inch of dimension.	±0.0003	±0.0003	±0.0005	±0.0008	±0.0008	±0.0015
K—dimensions between moving cores housed at right angles in the same die member.	Basic variation.	+0.004 −0.002	+0.004 −0.002	+0.006 −0.002	+0.008 −0.004	+0.008 −0.004	+0.010 −0.005
	Add for each inch of dimension.	±0.0003	±0.0003	±0.0005	±0.0008	±0.0008	±0.0015
L & *M*—dimensions between moving cores housed in opposite die members taken at right angles to (M) and parallel to (L) the plane of die parting.	Basic variation *L*. Basic variation *M*.	±0.004 +0.005 −0.002	±0.004 +0.005 −0.002	±0.006 +0.008 −0.002	±0.006 +0.010 −0.003	±0.006 +0.010 −0.003	±0.010 +0.017 −0.005
	Add for each inch of dimension.	±0.0003	±0.0003	±0.0005	±0.0008	±0.0008	±0.0015
N—dimensions parallel to the plane of die parting between opposed moving cores in opposite die members	Basic variation. Add for each inch of dimension.	±0.005 ±0.0003	±0.005 ±0.0003	±0.007 ±0.0005	±0.007 ±0.0008	±0.007 ±0.0008	±0.010 ±0.0015
P & *Q*—dimensions between a moving core and a fixed location in the same (P) or opposite (Q) die member, taken parallel to the plane of die parting and the axis of core withdrawal.	Basic variation *P*. Basic variation *Q*. Add for each inch of the dimension.	+0.003 −0.001 ±0.004 ±0.0003	+0.003 −0.001 ±0.004 ±0.0003	+0.004 −0.001 ±0.006 ±0.0005	+0.006 −0.002 ±0.008 ±0.0008	+0.008 −0.002 ±0.008 ±0.0008	+0.009 −0.003 ±0.010 ±0.0015
S—Possible variation due to warpage and other factors between two identical dimensions (see *A*) taken between different pairs of locations across the plane of die parting.	Variation for each inch between the pairs of locations *S*.	0.0003	0.0003	0.0005	0.0008	0.0008	0.0015

As difficult as the metals supply may look today on the merry-go-round of civilian products, things may not be as bad as they seem.

If you have been using nickel-bearing stainless steels, there may be other metals you can use to get you over the hump. These include chromium stainless and other special-purpose steels.

PERHAPS WE CAN HELP

This is where Armco engineers may be able to lend a hand. They will be glad to talk things over—perhaps offer suggestions that will help you make the most effective use of available metals.

If you are working on "DO" jobs and need Armco Stainless Steels, chances are we can supply them.

NEW STAINLESS GRADES

Four new grades of Armco Stainless may fit into your defense jobs. They are two extra-low carbon types, and two "precipitation hardening" grades.

Armco Type 304 ELC and Type 316 ELC have maximum carbon content of .03%. Type 304 ELC may be a suitable alternate for Type 347. It can be used in place of columbium-stabilized stainless for welded equipment if service temperatures are below 800 F.

Armco 17-7 PH and 17-4 PH are two unusual chromium-nickel types. They possess good workability and corrosion resistance, and attain high strength and hardness upon heat treatment. For many applications only a low-temperature heat treatment at 850-900 F is required to attain hardness of Rockwell C40-45 for 17-4 PH, and Rockwell C50 or better for 17-7 PH.

Write for complete information about these new stainless steels.

ARMCO STEEL CORPORATION

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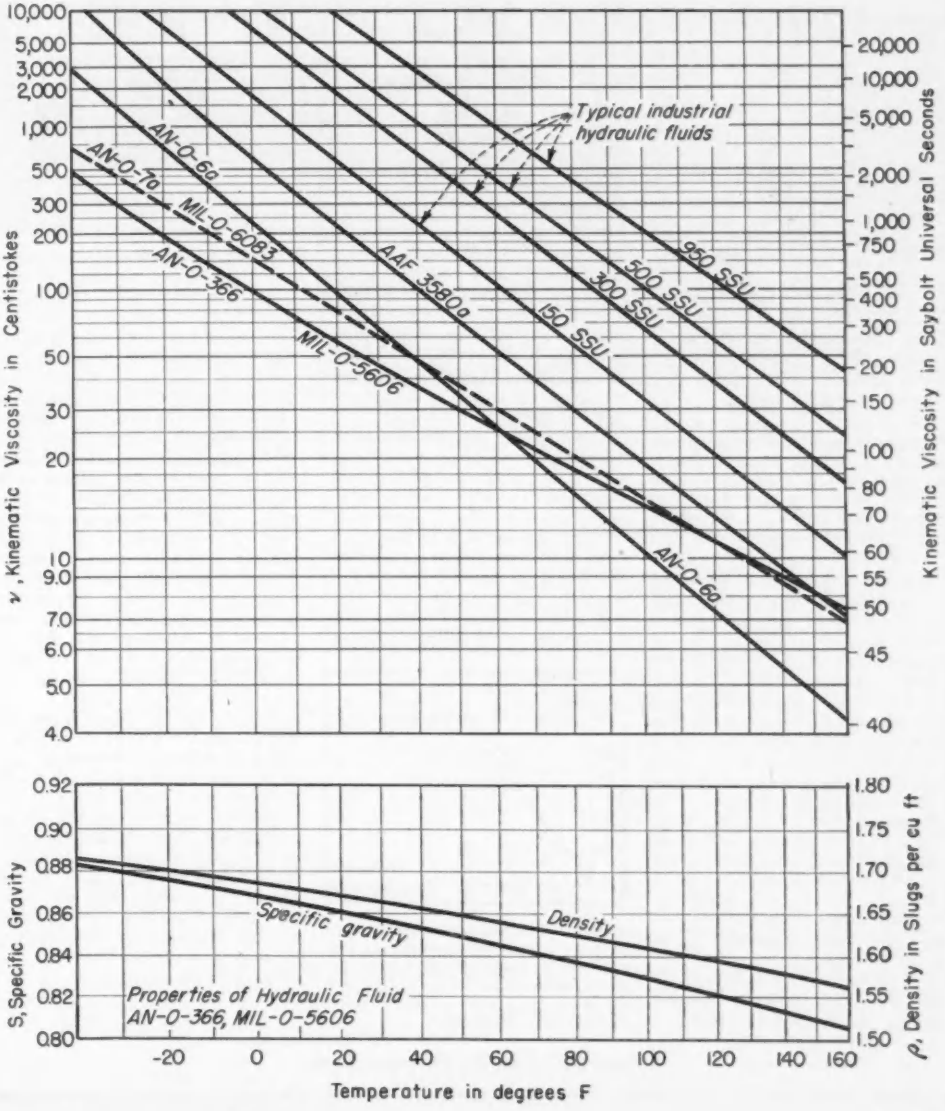
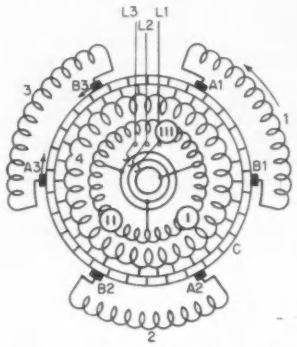
Kinematic Viscosity Curves of Hydraulic Fluids

N. M. SVERDRUP
Hydraulic Engineer, Aerojet Engineering Corporation



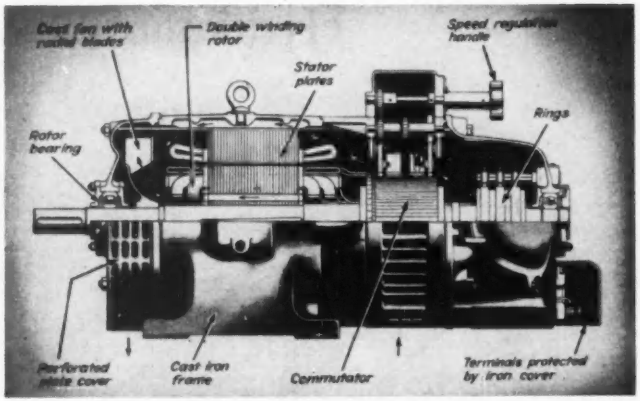
New Version of Adjustable Speed Motor



WINDING DIAGRAM displays the manner in which changing the relationship of the brushes alters the speed of the motor. Difference between top and bottom speeds and rated speed depends on the voltage generated from the regulated windings.

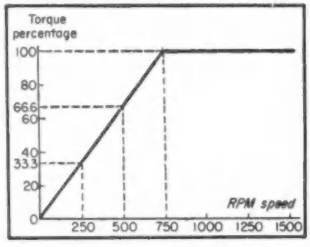
A recent import is a 60 cycle 220 v-440 v induction motor of the Schrage type whose speed can be regulated from 0 to 2,400 rpm by altering the relative position of its brushes through a speed regulation handle. It is designed to work at constant torque and adjustable speeds but it can also be operated at rated torque from maximum speed down to 750 rpm and then at decreasing torque in relation to speeds below 750 rpm.

A number of other operating characteristics are also of interest. For one thing, all motors have a rated speed of 1,200 rpm and a maximum speed of 2,400 rpm. Second, the motor can always be started across the line providing the brushes have been set in position for minimum speed. If it is desired to start the motor without altering the brush position (without changing the set speed) resistances must be used, but they can be short circuted after starting. Third, because at full load the power factor is near one, the use of the motor can improve the power factor of the whole plant.



ADJUSTABLE SPEED MOTOR operates on 220 v-440 v 60 cycle current and comes in 1.5 to 15 hp sizes. Speed can be varied from 0 to 2,400 rpm by turning the speed regulation handle which resets the brushes.

The operating characteristics of this adjustable speed motor result from a construction which consists of 3 windings. One is a rotor winding similar to that of an induction motor but connected to the network through 3 slip rings. The second is a regulating winding, similar to that of a d-c generator connected to a commutator on which there are three sets of brushes, (two per set) one set for each pair of poles.



TORQUE is constant as speed decreases down to 750 rpm but varies directly with speed below that point. This is but one of the operating conditions under which the motor will operate. Another is constant torque at all speeds.

The third is a stator winding similar to that of an induction motor, but the phases are electrically separated and are connected at their two ends to each pair of brushes on the commutator.

The diagram indicates the method of connecting the windings. In I, II and III are shown the primary windings connected to the network L_1, L_2 and L_3 by means of the collector slip-rings. The stator or secondary windings, are 1, 2 and 3, and 4 shows the regulating windings connected to the commutator C. When the brushes A_1-B_1, A_2-B_2, and A_3-B_3 are in line and adjacent on the commutator, the secondary windings 1, 2 and 3 are short-circuited and the motor operates like an ordinary induction motor.

If the brushes A_1, A_2 and A_3 are separated from brushes B_1, B_2 and B_3, a voltage is collected between each pair of brushes, which will increase with the number of blades separating the two brushes, such as A_1 and B_1, on the commutator. This voltage will apply itself to the secondary windings 1, 2 and 3. At no-load running, the effect of the revolving field will be to cut the stator windings, inducting these with an equal and opposite voltage to the succeeding one, and the motor will revolve at a non-rated speed.

Belgium Electric Sales Corp., 1 E. 53rd St., New York, N. Y.

Circle No. 1 on Reader Service Card

Wide Application for Automatic Fuel Pump

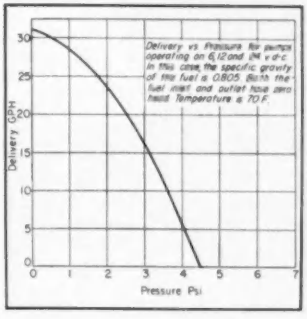
Five years of research and development have brought into being an automatic electric fuel pump for supplying fuel to carburetors. While the pump was designed principally for automotive use, its compact design and performance characteristics make it applicable to other fuel transfer requirements. For example, it is employed in military installations for supplying fuel to coolant heaters and space heaters. It may also be employed for light aircraft carburetion or fuel injection.

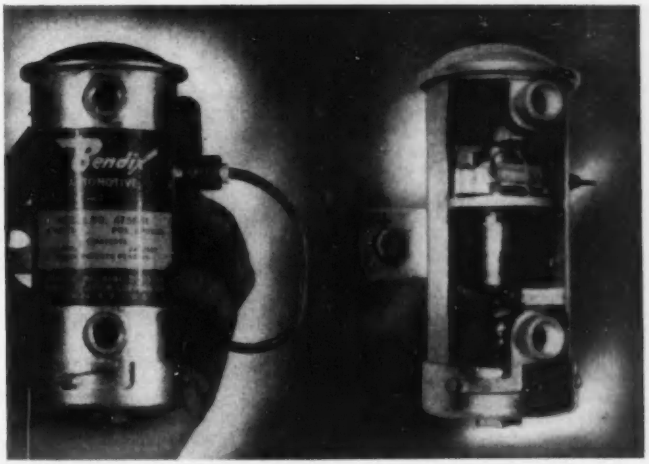
A single pump will deliver up to 30 gal per hour at static pressures up to 7.0 psi. For larger requirements two or more pumps are manifolded in series or parallel. Simplicity of design featuring an interrupter system and hermetic sealing of all electrical components are said to give it long life.

The pump is powered by a solenoid. Pumping is achieved by the movement of a hollow plunger controlled by an interrupter in the electrical circuit; neither a sylphon or rubber diaphragm is used. This, it is pointed out, permits a smooth, steady output of fuel at temperatures down to —75 F. Its low power requirement is 7 watts at maximum fuel delivery.

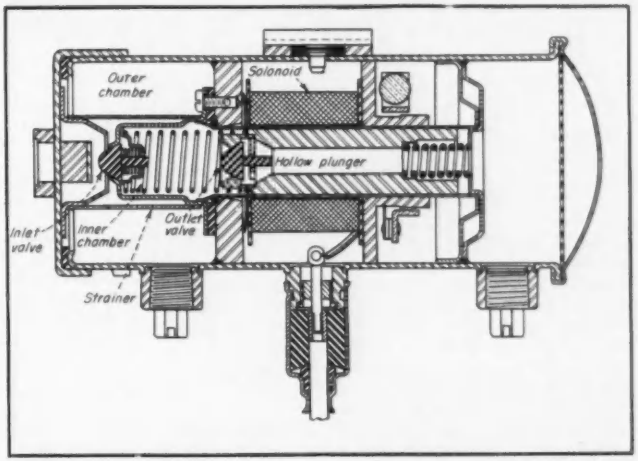
Pumps now in production are for operation on 6, 12, and 24 volts d-c; a 110 v a-c version is under development. A radar and radio suppressed model is also available.

Bendix Aviation Corp., Eclipse Machine Div., Elmira, N. Y.


Delivery vs Pressure for pumps operating on 6, 12 and 24 v d-c. In this case the specific gravity of the fuel is 0.805. Both the fuel inlet and outlet hose zero head. Temperature is 70 F.
Delivery GPH
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7
Pressure Psi



ELECTRIC FUEL PUMP is powered by a solenoid controlled by an interrupter in the electrical circuit. The solenoid, in turn, actuates a hollow plunger which periodically delivers a fixed quantity of fuel to the carburetor. Since neither a sylphon or rubber diaphragm is used, output of fuel, it is said, is smooth and steady.

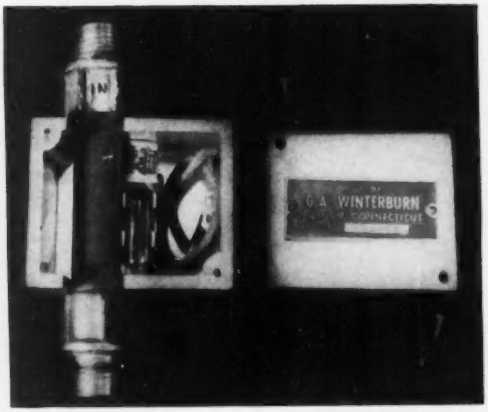


ACTUATION OF SOLENOID moves hollow plunger to right to deliver its fuel. Upon release, hollow plunger moves back into fuel filled inner chamber where pressure exerted on fuel forces outlet valve to open and fill hollow plunger. As hollow plunger moves to right again under solenoid actuation, partial vacuum created in inner chamber causes outlet valve to close and inlet valve to open to draw in more fuel.

Circle No. 2 on Reader Service Card

CONTINUED ON PAGE 176

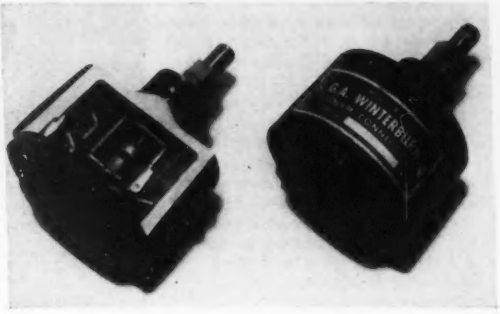
Magnetic Switches Give Specialized Service



MAGNETICALLY COUPLED FLOW SWITCH, which is constructed of brass pipe and fittings with monel inserts in a cast aluminum electrical housing and designed for vertical pipe mounting, will indicate flow in a pipe from 5 gpm to maximum at pressures up to 150 psi through either normally open or normally closed switches. Unless otherwise specified, the normally open switch is supplied. Flow is adjusted as required by the user. Contacts are rated at ½ amp, 110/220 v a-c; ¼ amp, 125 v d-c; 1 amp 24 v a-c or d-c. Fittings are ¾ IPS for ½ in. orifice.

In operation, the liquid is diverted by a moveable vane to which are attached 2 plexiglass enclosed Alnico magnets. One of these prevents chatter. The other actuates the vane of a sealed mercury switch located outside the pipe but inside the housing.

The switch can be used as a safety device to prevent operation of spot welders, induction hardening machines, and washing machines unless the water supply is turned on first. Another function that the switch can perform is as the holding contact for the main line switch with a relay.



ROTARY MAGNETIC SWITCH, said to perform accurately up to 1,500 rpm, gives positive action without cam or springs. Rotation can be in either direction, and the switch can be suspended from the shaft alone in any position. Its contacts are rated as single pole, single throw, and they are capable of carrying 5 amp non-inductive at 110 v 60 cycles. The drive shaft length and leads are furnished to the customer's specifications.

The rotary magnetic switch has been developed in particular for use in the textile industry where it is employed in conjunction with electric counters, flashers, safety shut off devices, and for time studies. However, it can be adapted for mechanisms in other industries where rotary switching action is needed.

Winterburn Mfg. Co., Putnam, Conn.

Circle No. 3 on Reader Service Card

Laminate Is Strong in All Directions

Uniform high physical strength is the outstanding characteristic of a recently announced phenolic laminate reinforced with unwoven cotton fibres random laid in the form of a mat. Good electrical characteristics and low moisture absorption are also claimed for the material. It can be lathe turned, milled, drilled, shaped and threaded in much the same manner as hard brass although for best results the cutting tool should have a slightly greater rake angle. The surfaces produced are comparable in smoothness to those obtained with a dense paper base laminate.

These characteristics make this material suitable for a number of parts that are made of non-metallic material. In the mechanical field these include gears, cams, pinions, textile bobbin heads, and other high strength parts. Its electrical characteristics suit it to electrical parts requiring high uniform mechanical strength.

Characteristic Properties

Water Absorption (24 hr), percent	0.7
Expansion after 24 hr immersion at 77 F, in	0.0020
Specific Gravity	1.34
Unit Weight, cu in. per lb	20.6
Power Factor at 1 Megacycle	0.07
Dielectric Constant at 1 Megacycle	5.1
Loss Factor at 1 Megacycle	0.35
Dielectric Strength (perpendicular to lamination) vpm	300
Insulation Resistance, megohms	200
Tensile Strength in any direction, psi	15,000
Flexural Strength in any direction, psi	22,000
Compressive Strength, Flatwise, psi	45,000
Compressive Strength, Edgewise, psi	22,000

Richardson Co., 2735 Lake St., Melrose Park, Ill.

Circle No. 4 on Reader Service Card

CONTINUED ON PAGE 178

New Book Tells How to
SPEED URGENT PRODUCTION!

Get complete precision stamping service!

Use specially engineered parts!

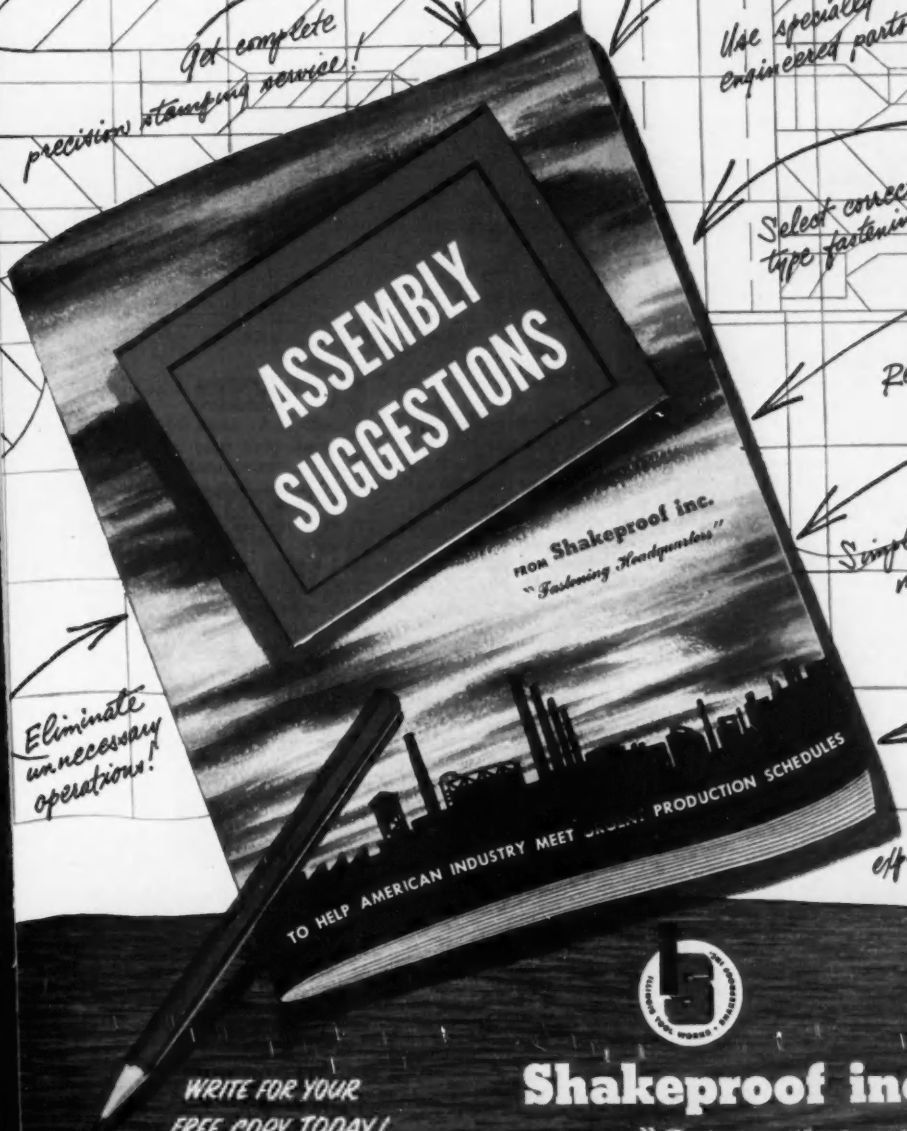
Select correct type fastenings!

Reduce machine bottlenecks!

Simplify assembly methods!

Eliminate unnecessary operations!

Counsel with experienced assembly specialists!



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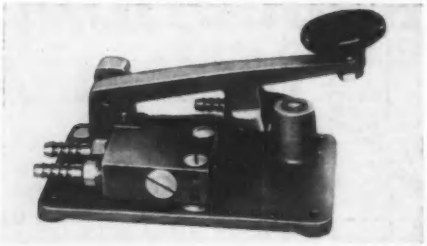
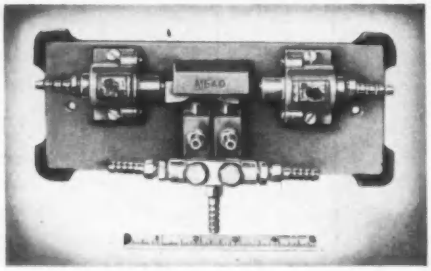
Shakeproof inc.

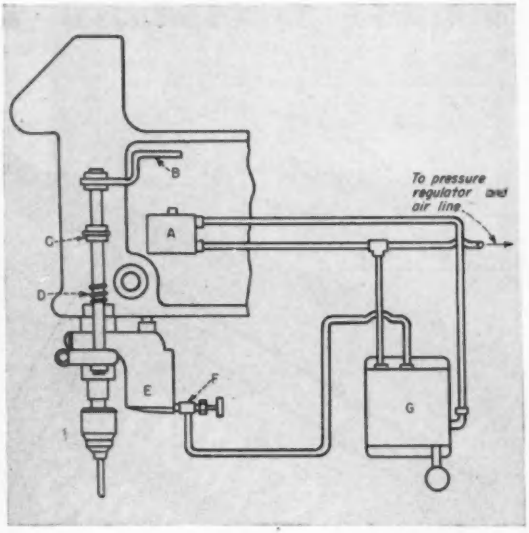
"Fastening Headquarters"

Division of Illinois Tool Works
2501 North Keeler Avenue, Chicago 39, Illinois
In Canada: Canada Illinois Tools, Ltd., Toronto, Ontario

Timers Cut Non-Productive Time







Waiting time spent by the operator while a machine operation is performed can be done by one of these pnuematic timers. The operator starts the cycle and the timer stops it. The waiting period can be used by the operator to load a second machine or a battery of machines while the first is working. Thus production is increased, and operator fatigue caused by the involuntary nervous strain of watching for the end of each cycle is reduced.

There are two models. The simpler (upper photograph) operates a single-acting cylinder. A spring, in this case, actuates the return motion. The more complex timer operates a double-acting cylinder as well. With this one, a limit valve placed where it will be tripped by the forward motion of the machine causes the timer to shut off air from the forward moving air cylinder and admit air to propel the return motion.

Timer hookup for a drill press permits timer to watch the operation and shut off the machine at completion of the job. (A) Limit valve attached to the drill press head casting. (B) Limit valve arm adjusted to open limit valve as depth stop nut reached the end of travel. (C) Depth stop nut. (D) Break through spring for through holes only. (E) Feed. (F) Speed control valve. (G) Timer shuts off cycle air permitting machine to return to starting position ready for operator to press timer button again.

Mead Specialties Co., Dept. T44-, 4114 N. Knox Ave., Chicago, Ill.

Circle No. 5 on Reader Service Card

Lubricator Produces Fog of Oil Particles

Each drop of oil which enters its oil bowl is broken down by this lubricator into fine particles of uniform sizes, 2 microns (0.00007874 in.) or less in diameter, which are carried into the air stream. The relatively dry oil fog composed of the oil particles in the air stream is capable of complete suspension over long distances and long periods of time, and it becomes wettable only when subject to reclassifying action at the final point of application. Moreover, because the fine oil particles remain in suspension, multiple units in simultaneous operation can be lubricated uniformly. All flow requirements, too, are low.

Approximately 5 percent of the oil flow seen in the sight feed glass is converted into the fog which is carried into the air stream. The rest is returned to the oil supply. This means that oil can be metered to as little as one drop per 20 min. Since no oil drops enter the line, the possibility of oil collecting in the lines or flooding the equipment is believed to be remote. The lubricator is automatic. It starts to operate as soon as the air flows and stops when the tool or machine stops.

Lubrication applications for which this type is suitable include, high speed parts, multiple devices, closely fitted parts, and operations in which a minimum quantity of oil is permitted. The lubricator comes in 8 models.

G. A. Norgren Co., 222 Santa Fe Dr., Denver, Colo.

Circle No. 6 on Reader Service Card

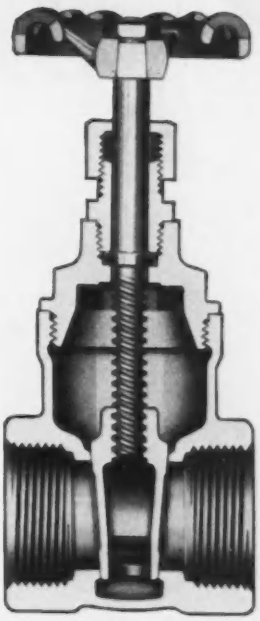
CONTINUED ON PAGE 181

Big help on Piping design ...your CRANE Catalog

Big help in more ways than one, too. Your Crane Catalog saves specifying time—everything you need is carefully cataloged and cross-indexed for quick and easy selection. And "everything" at Crane means the world's most complete assortment of valves, fittings, pipe, and piping accessories.

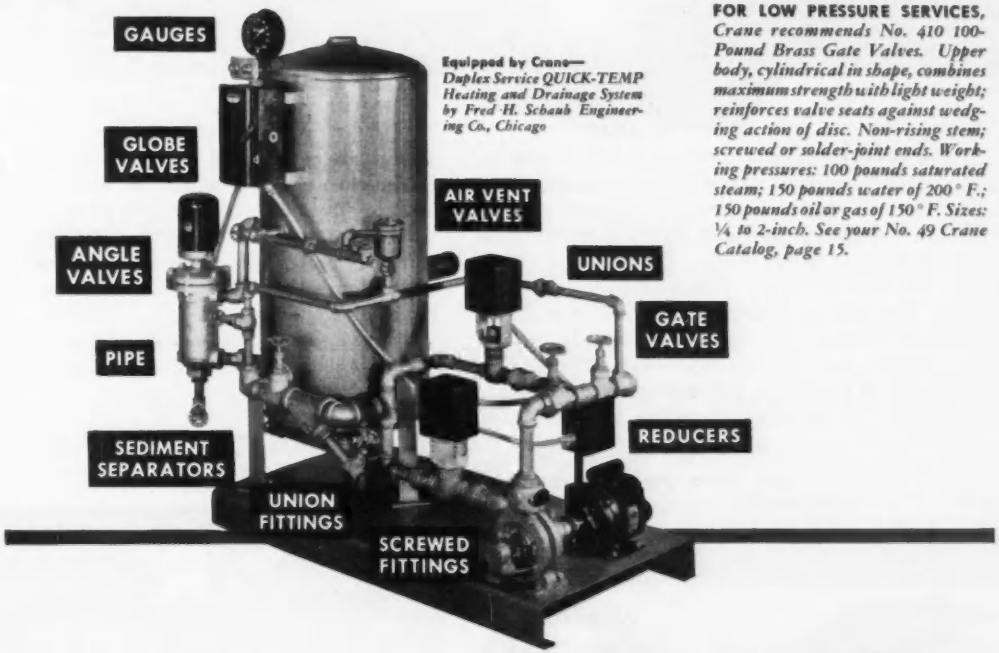
Making Crane your single source of supply simplifies other piping procedures, too—ordering, storekeeping, and final product assembly, for example. Most important—especially today—your product has added customer appeal when all piping is Crane. For machinery buyers know from experience that Crane Quality and "top quality" are one and the same.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas



FOR LOW PRESSURE SERVICES, *Crane recommends No. 410 100-Pound Brass Gate Valves. Upper body, cylindrical in shape, combines maximum strength with light weight; reinforces valve seats against wedging action of disc. Non-rising stem; screwed or solder-joint ends. Working pressures: 100 pounds saturated steam; 150 pounds water of 200° F.; 150 pounds oil or gas of 150° F. Sizes: ¼ to 2-inch. See your No. 49 Crane Catalog, page 15.*

FOR A BROADER SELECTION OF BETTER PIPING ...LOOK TO THE CRANE LINE



Equipped by Crane— *Duplex Service QUICK-TEMP Heating and Drainage System by Fred H. Schaub Engineering Co., Chicago*

EVERYTHING FOR EVERY PIPING SYSTEM

CRANE

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING

C/R

BLACK MAGIC

It's not really magic, of course. Simply a scientific understanding of your need for a critical pliable part. It may be a seemingly "impossible" part . . . completely unusual in physical properties and operational characteristics. But, it is a part you *must* find to complete your mechanism.

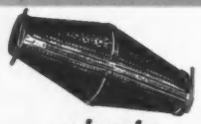
Working from your specifications, Chicago Rawhide's Sirvene engineers will produce the needed design, compound the right combination of oil-resistant elastomers, and mass-produce your part under strictest laboratory control. You'll have the *exact* degree of flexibility, hardness, resistance to extreme temperatures, fluids, gases, abrasion and wear, or other qualities you may require

Whether the part is an intricately designed diaphragm or boot . . . or is a simple but critical gasket, you may be sure it will function exactly as you require.

Sirvene has served dependably in thousands of unusual or difficult situations. It can do the same for you.

ENGINEERS: For basic information, write for your copy of "Engineering with Sirvene". There is no charge.

CHICAGO RAWHIDE MANUFACTURING CO.
1299 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois



sirvis

Mechanical Leather Products
Boots, diaphragms, packings and other products give dependable service under difficult operating conditions.

***PERFECT* Oil Seals**

C/R seals are used in more motor vehicles, farm implements and industrial machines than any other shaft-type sealing device.

C/R
SIRVENE
THE *SCIENTIFIC* COMPOUNDED ELASTOMER

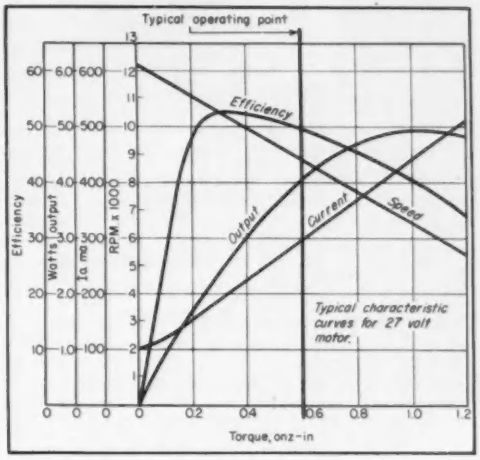
Boston • New York • Syracuse • Philadelphia • Pittsburgh
Cincinnati • Cleveland • Detroit • Peoria • Minneapolis
Kansas City • Houston • Los Angeles • San Francisco

D-c Machines Follow Miniturization Trend

A line of miniature, permanent magnet field type, d-c motors and generators has recently been placed in production. These units are 1⅛ in. in dia by 1½ in. long. The weight is approximately 2½ ounces. Motor voltage ratings of from 6 to 28 volts are available in this standard frame size. Varied applications of these precision ball bearing motors range from aircraft electronic equipment blowers to telemetering sequence switches. Front flange or base mounting types are available in all voltage ratings.

The 27 v motor provides four watts of mechanical shaft output power, and at that power operates at approximately 50 percent overall efficiency with a temperature rise of 45 F. This model may be used as a generator providing an output voltage of approximately 2 v per 1,000 rpm at driven speeds up to 12,000 rpm. This output voltage may be developed across a load resistance of as low as 10,000 ohms with proportional linearity. Thus the unit may be used as a tachometer generator or as a rate generator in various types of servo systems.

As for design and construction details, instrument type ball bearings allow for safe high speed operation up to 12,000 rpm over wide temperature ranges. A cylindrical, or ring type, Alnico V field magnet is utilized, thus doing away with the need for pole shoes or for the usual steel or iron frame for such a motor. This field magnet construction provides its own magnetic return path and allows the use of an aluminum motor housing shell. The light weight of this motor makes it desirable for applications where every ounce is at a premium. A 14 segment wafer type commutator is utilized whereby brushes are inserted through the rear bakelite end cap. This makes side projections unnecessary and keeps the motor within minimum clearance dimensions.



Servo Tek Products Co., 4 Godwin Ave., Paterson, N. J.

Circle No. 7 on Reader Service Card

Line of Selenium Rectifiers Rated to 25 Kw

Claimed to operate at efficiencies from 81 to 84 percent, a new line of metal enclosed d-c power supplies utilizing selenium rectifier stacks may be used for excitation of synchronous motors, operation of d-c elevators, cranes and machine tools, conversion of a-c feeders to d-c and other applications. The power factor is 95 percent.

Designed for indoor installation, the rectifier units are mounted in a metal casing consisting of one to four separate sections, mounted vertically, one on top of the other, and bolted together. A removable front, wire-mesh panel permits access to all component parts. Reliable control and operation is assured by built in contactors with thermal overload protection and fused disconnect switches.

The units can be furnished to supply either 125 or 250 v d-c from a 230 or 460 v, 3 phase, 60-cycle a-c supply. Convection-cooled equipments are available in ratings of 0.75, 1.5, 3, and 5 kw. Fan-cooled units are rated at 7.5, 10, 12.5, 15, 18.5, 20, and 25 kw. When larger ratings are required two or more rectifier units may be connected in series and/or parallel to increase the current or voltage rating of the installation. Built without moving parts, except for the fan in the higher-rated units, the power supplies need little maintenance. The fan requires greasing approximately twice a year.

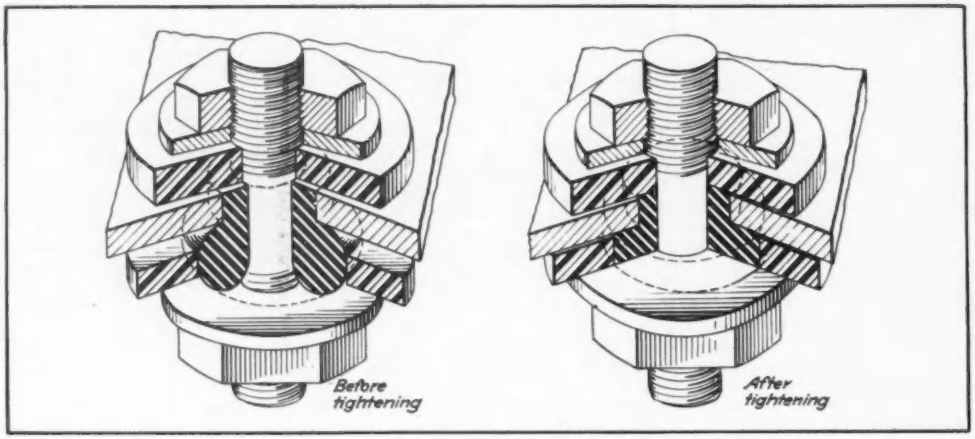
This line of selenium rectifiers, it is pointed out, is the product of a continuing research and development program designed to improve the operating characteristics of this type of unit while, at the same time, reducing its weight and similar factors.

General Electric Co., 1 River Rd., Schenectady, N. Y.

Circle No. 8 on Reader Service Card

CONTINUED ON PAGE 182

Rubber Ring Seals Electric Terminals



Positive and permanent sealing of electrical terminals in the pressure of fluids is provided by a rubber sealing gland shaped like an O. Neoprene is used for the temperature range —67 F to 225 F, and for the range —100 F to 500 F silicon rubber is employed. The unit, complete with studs and insulators, is designed for voltages up to 12,000 and for high frequencies.

The combining of the sealing ring with the high voltage terminal is said to produce true hermetic sealing without increased bulk or loss of desirable features of the terminal itself. Moreover, because it is fully retained within rigid members, the sealing ring does not undergo excessive stretching and consequent failure. This design increases the useful life, prevents loss of electrode torque through cold flow and provides ease of installation.

The method of sealing is based on the fact that rubber when released from pressure tends to return to its original shape. An "O" shaped rubber ring, compressed into a square section, is an adaptation to sealing. The resulting configuration insures maximum recovery tension with a minimum of rubber volume. Since the rubber is never stretched beyond its elastic limits, recovery is maintained almost indefinitely.

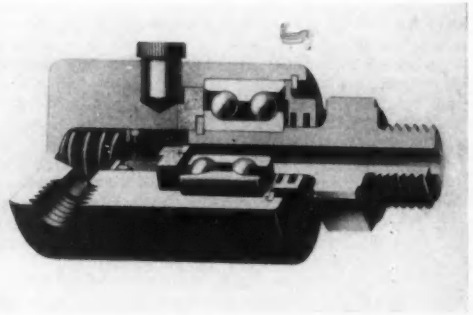
Franklin C. Wolfe Co., Inc., 11723 Mississippi Ave., Los Angeles 25, Calif.

Circle No. 9 on Reader Service Card

Seal for Fluids Passing to Rotating Members

Rotorseal, a mechanism for the transmission of air, liquids and gas from stationary to rotating machine members is now generally available. Sealing is provided by a non-metallic seal held against the Rotorseal shaft by spring pressure. Connection to the rotating member is made by screwing the male end of the unit into a properly aligned, drilled and tapped mating hole in the end of the applicable shaft.

The single passage Rotorseals shown are available in sizes from $\frac{1}{2}$ to $1\frac{1}{2}$ in. pipe thread for operating speeds to 2,500 rpm and maximum operating pressure of 150 psi. Multiple passage units for transmitting several different mediums through different passages come in $\frac{1}{4}$ to $\frac{1}{2}$ in. pipe thread series.



Fawick Airflex Co., Inc., 9919 Clinton Rd., Cleveland, Ohio

Circle No. 10 on Reader Service Card

CONTINUED ON PAGE 184

Now, more than ever before, America must make full use of its steel-making capacity and conserve its natural resources. Now, more than ever, there is national significance in the phrases, "*Make a ton of sheet steel go farther*" and "*Make your product last longer.*"

These low-alloy, high tensile steels do "make a ton of sheet steel go farther"—for their inherently higher strength is 50% greater than mild carbon steel. That means, in turn, that 25% less section can be used with safety, and where rigidity is important, this can usually be compensated for through slight design change.

"Make your products last longer" is no idle claim. The much greater resistance of N-A-X HIGH TENSILE to corrosion, abrasion, and fatigue assures longer lasting products even at reduced thickness.

Explore the potential economies to be derived from the use of low-alloy, high-strength steels—and then specify them. Their use can add materially to our national conservation program.

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division, Ecorse, Detroit 29, Michigan

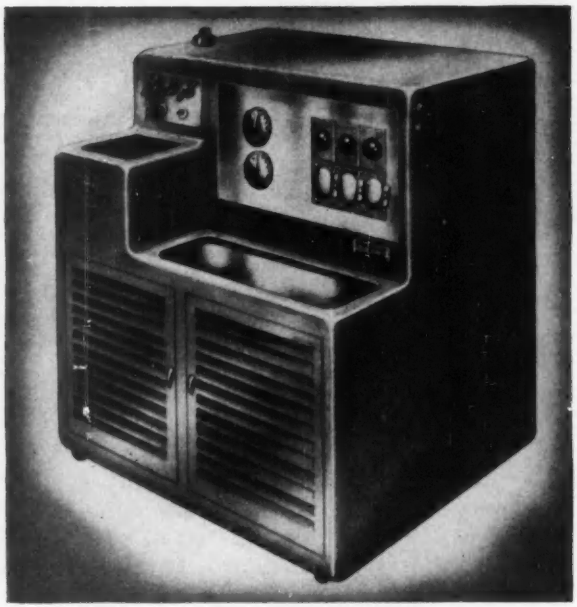
NATIONAL STEEL CORPORATION

Test Stand Simulates Flight Temperatures

Among the problems of manufacturers of aircraft components is that of determining the operating characteristics of sub-assemblies of aircraft components at temperatures equivalent to those encountered in actual flight conditions. The solution to this problem can be provided, it is claimed, by a test stand that will produce any temperature between —70 F and +230 F.

The test stand has a well which can accommodate small aircraft parts measuring up to 6x 6 x 8 in. The item to be tested is placed in the well and the thermal selector set at the desired temperature. The part under test assumes the temperature of the deep well and can then be withdrawn and checked for operation. To accommodate testing of small parts that are mounted on larger assemblies and cannot be placed in the deep well, the thermal fluid can be circulated in a closed system a short distance from the test stand in insulated lines.

Compact and mobile, the test stand measures 30 x 40 x 54 in. It is completely self-contained and requires only a power and a water supply. Electricity and cooling water are conducted in flexible conductors to maintain mobility. The refrigerant is a metho-ethanol solution.



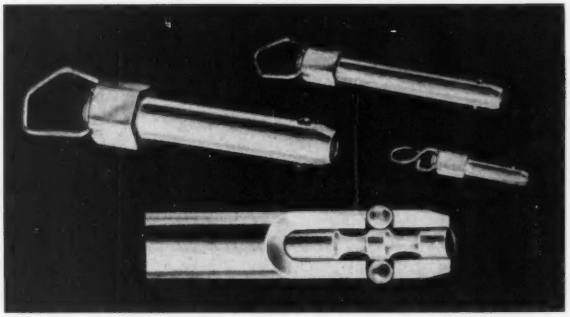
Electro Mechanical Devices Div., Geo. L. Nankervis Co., 19255 W. Davidson, Detroit 23, Mich.

Circle No. 11 on Reader Service Card

Pip Pin Replaces Bolt and Nut Assembly

Here is a fastener, called "pip" pin, that can be used to replace the bolt and nut or bolt and cotter pin assembly. As such it is particularly useful where the design of mechanical equipment and machinery make the more conventional fastener difficult to assemble. Once in place it cannot work loose but must be deliberately removed to effect disassembly of any units being held. It can be used for shackle purposes or as a tie-down fastening and is capable of taking high shear and axial loads.

The pin's design employs a mechanical locking arrangement. Inside the pin is a spring-loaded steel spindle whose large diameter in a normal position bears against steel balls, holding these out so they project beyond the outer surface of the pin and thereby act as a lock. When the spindle is moved until its small diameter is between the steel balls they are able to recede flush with its outer surface, thereby allowing this quick release pin to be withdrawn.

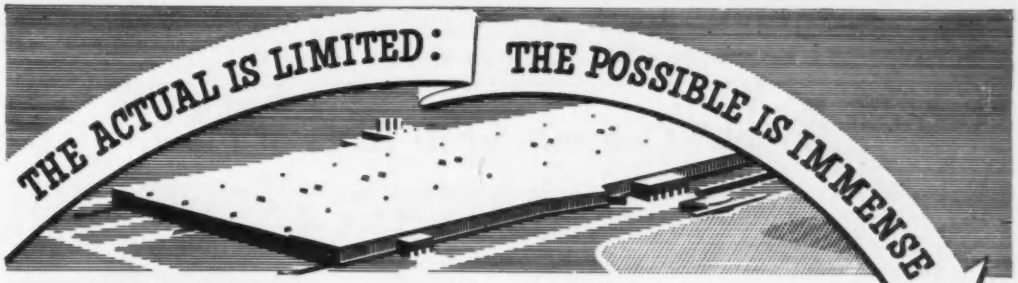


AWKWARD FASTENER PROBLEMS in which difficulties due to the design of the equipment are encountered in assembling a bolt and nut can be solved with a "pip" pin. Projecting steel balls act as a lock, but they recede flush with the outer surface of the pin when its spring loaded spindle is moved.

Aviation Development, Inc. 2940 N. Hollywood Way, Burbank, Calif.

Circle No. 12 on Reader Service Card

CONTINUED ON PAGE 186



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

© LE Co. 1951

DESIGNS THAT UTILIZE THE ECONOMIES OF WELDED STEEL ARE ALWAYS LOWER IN COST

1 There is a 2 to 1 advantage pound per pound between the cost of steel and iron.

2 Considering both strength and safety factors, there is an additional 4 to 1 advantage with steel.

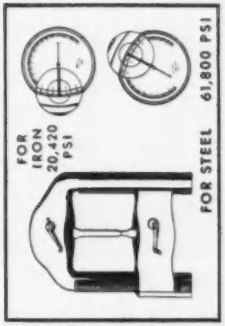
3 The design advantages are unlimited. Through origineering,* the designer is better able to locate the stronger materials in strategic areas, achieving maximum load-carrying capacity per pound of metal.

4 Production efficiency is greater. The shop can fabricate economically in any quantity . . . with a minimum of equipment and setup cost.

A Challenge to Industry

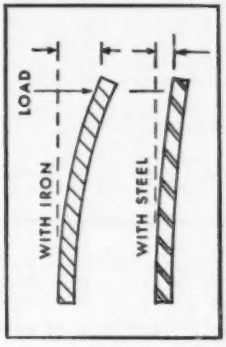
The greater potential economies possible with welded steel originate with design. To utilize the full benefits of steel requires new concepts in mechanics and appearance. Your Lincoln Welding Engineer can show you how to achieve these benefits in your designs . . . to build better products from less material at lower cost. Write The Lincoln Electric Co., Cleveland 1, Ohio.

*Origineering . . . the science of originating new engineering designs.



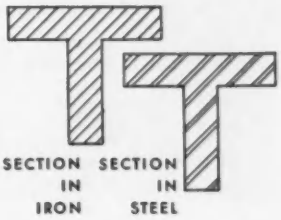
Steel is 3 Times Stronger. *Has 4 times the resistance to fatigue.*

Steel is Ductile. *Withstands impact and shock without fracturing.*



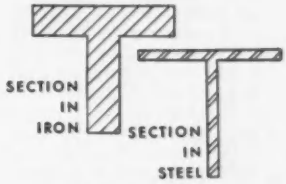
Steel is Twice as Stiff. *Only half the material is needed in welded steel designs to achieve equal rigidity.*

the ACTUAL



Saves 50% Material Cost *by duplicating cross section in steel.*

increasing the YIELD



Needs 60% Less Metal *to achieve equal strength in bending.*

the IMMENSITY of the POSSIBLE

An initial 7 to 1 cost advantage with welded steel

SEE HOW WELDED STEEL CUTS COSTS

Machine Design Sheets are available to designers and engineers. Simply write on your letterhead to Dept. 34

THE LINCOLN ELECTRIC COMPANY

CLEVELAND 1, OHIO

Bubbler Controls Small Rates of Flow

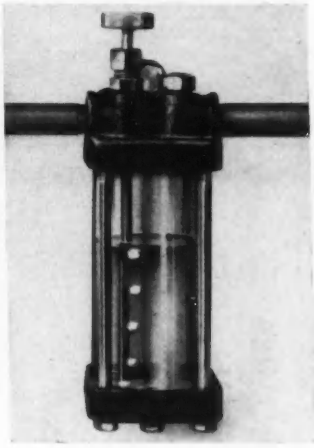
Relatively small rates of flow in gas and air lines are visually indicated and can be controlled by a bubbler. The entire flow is passed through the liquid in its transparent cylinder where the rate of flow is shown by the bubbles rising through the liquid. Any rate of flow from less than one bubble per second to 20 cu ft per hour can be secured by adjustment of a needle valve on top of the bubbler. The liquid used in the bubbler can be water, glycerine, kerosene or something similar.

One of the applications suggested for this product is use with hydrostatic liquid level gages to control and show the flow of compressed air required for continuous gaging independent of hand pumps. Another is for bleeding air into lines to purge them of corrosive fumes or gases.

Convenience of installation, observation and service has been the design aim. The dip tube is set off center and its bottom end is cut at an angle to direct the bubbles to rise near the center of the bubbler where they are readily observed without obstruction. The Pyrex glass cylinder has ground ends that form a seal against Neoprene gaskets at top and bottom. Four tie rods protect the cylinder against damage, and permit easy disassembly for cleaning.

With the needle valve, dip tube, and filter plug removed, the product becomes a sediment trap for collecting dirt and moisture from gas and air lines. As such it can handle a maximum flow of 6 cu ft per min at 25 psi differential pressure.

King Engineering Corp., Box 500, Ann Arbor, Mich.



Circle No. 13 on Reader Service Card

Coupling's D Shape Bore Eases Installation

Of interest to manufacturers of equipment that requires the use of electrical motors with ratings up to $\frac{1}{2}$ hp at 1,750 rpm is a coupling whose design is said to reduce operating noise, absorb torsional shaft vibration and accommodate angular shaft misalignment up to 2 deg and $\frac{1}{32}$ in. in parallel.

Hubs stamped from steel strip stock replace the customary machined or die-cast types. Oil resistant Neoprene is permanently bonded between two flanged hubs to produce a one-piece design. Since the Neoprene is stressed in shear, maximum torsional flexibility is obtained to absorb momentary irregularities of shaft speed, and thus provide smooth power transmission.

The unusual method of shaft attachment does away with the need for keyways, pins, and set screws. Die-formed hubs are drawn with such accuracy that the bore is held to a diameter tolerance of 0.002 in. One side of the hub is provided with a flat, resulting in a "D" shaped bore which mates with the milled flats on both motor and driven shafts.

Lord Mfg. Co., Erie, Penna.

Circle No. 14 on Reader Service Card

CUP TYPE PACKING for pneumatic and hydraulic equipment is claimed to perform satisfactorily under pressures as high as 3,000 psi. Molded from Neoprene and fabric, it comes in sizes from 1 to 24 in. OD. Rockwell Leather and Packing Co., 1638 Long Beach Ave., Los Angeles, Calif.

PHASE CONVERTER replaces bulky transformers for multi-phase telemetering equipment. It is a non-rotating unit with movable primary for initial setting. The outside shell is anodized for corrosion protection. It weighs 30 oz and is 3.5 in. long by 2.25 in. in dia. Ford Instrument Co., Long Island City, N. Y.

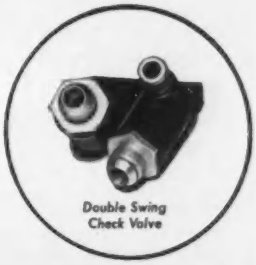
CORROSION RESISTANT FITTINGS, said to simplify installation, include an insert flange for whose assembly only an expanding tool and wrench are needed, an aligning connector for joining different size tubes and a sanitary tube and pipe union that is lightweight and gall free. Horace T. Potts Co., Erie Ave. & D St., Philadelphia, Pa.

HOSE CLAMPS in 6 sizes ranging from $\frac{1}{2}$ to 2 in. are made of stainless steel. Specialty Products Co., Cleveland, Ohio.

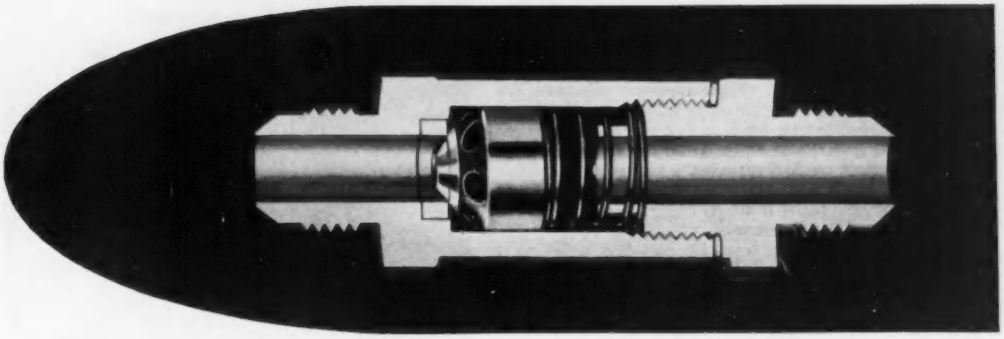
CONTINUED ON PAGE 188

KOHLER

PRECISION PARTS



Double Swing Check Valve



Cone Type Check Valve

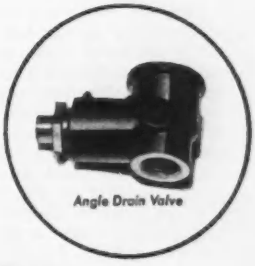
AIRCRAFT • INDUSTRIAL • AUTOMOTIVE

Solenoid Drain Valve

KOHLER PRECISION PARTS are used by manufacturers of Diesel engines, automobiles, trucks, tractors, jet engines, military, commercial and private aircraft, and for agricultural and industrial test equipment.

With an organization experienced and skilled in precision workmanship, Kohler maintains full facilities for forging, casting, machining, anodyzing, assembling, and testing.

Kohler engineers will develop precision valves and fittings for volume production to meet special applications. Write for a catalog and send your specifications or requirements.



Angle Drain Valve

Fuel Dump Valve

KOHLER CO., KOHLER, WISCONSIN. ESTABLISHED 1873

KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT

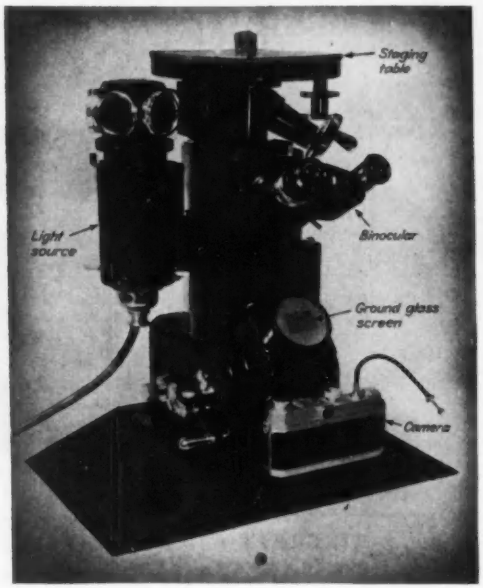
ELECTRIC PLANTS • AIR-COOLED ENGINES • PRECISION PARTS

Precision Microscope Speeds Microphotography

A product of France, this metalographic microscope is an instrument used in microphotography and inspection. It has been constructed with the objective in mind of providing proper support for heavy test samples and of producing speedy, precise results therefrom.

Attention has been given, for example, to the design of the staging table which is sufficiently rigid so that displacement is less than 0.00008 in. for every 3 lb of weight, and the adjustable column supporting the staging table is designed to prevent play in the mechanism yet allow easy and smooth adjustment. Three types of adjustment are available for controlling elevation of the staging table: a fine adjustment by cam action, a fast adjustment by screw action, and an eccentric action which disengages the other two adjustment mechanisms when a change in magnification is desired. The staging table may also be rotated about the vertical axis, but it is always centered exactly with the optical axis of the microscope.

The magnified image may be projected either to a ground glass screen or to the camera film by bringing a prism into or out of the system. Focusing on the ground glass automatically focuses the image on the film. In either case the amount of enlargement of the image is the same. Illumination is obtained from an 8 volt concentric filament bulb mounted in a five-position turret. Instantaneous selection of five different filter lenses is obtained by rotating the turret. All lens systems are corrected for infinity and the photographic projectors are of the diverging type.



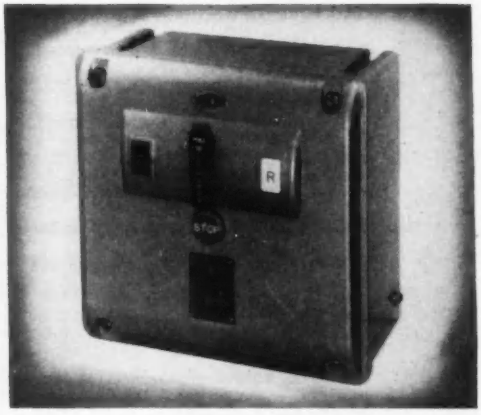
F. T. Griswold Mfg. Co., Wayne, Penna.

Circle No. 15 on Reader Service Card

Reversing Motor Starter Cuts Maintenance

Forward, reverse and stop buttons, isolator unit, fuses and overloads are contained in a compact reversing starter that is said to be capable of no less than 60 reversals per minute. This unit is, in effect, two starters in one—forward and reverse. Operation of the forward (F) button engages contacts electromagnetically and actuates a pivoted arm that throws the reverse contacts out of circuit. Pressing the reverse (R) button similarly throws the forward contacts out of circuit. Quick substitution for maintenance purposes is readily accomplished because the whole mechanism of starter, reverser, isolator, fuses and overloads is mounted on the cover, which can be withdrawn by removing four screws.

The starter, which is $8\frac{1}{16}$ in. high, $4\frac{7}{8}$ in. deep and $5\frac{13}{16}$ in. wide, is set in a plastic base fitted with metal inserts. The rewirable fuses are interchangeable. It has indirectly heated thermal overloads fitted on three phases with infinitely variable adjustment. All mains contacts are silvered, and no-volt release is inherent. The whole unit is housed in a metal case and can be supplied for surface or flush mounting. Motors from $\frac{1}{4}$ to $7\frac{1}{2}$ hp at 200 to 440 v and from 0.25 to 11 amps can be accommodated.



Ega Electric Ltd., Wednesbury, England

Circle No. 16 on Reader Service Card

CONTINUED ON PAGE 190

Why UNBRAKO "STANDARDS"

"Standards" keep you in the BLACK

Standard design and purchase | Standard tools | Standard (fast) production with "standards" from stock | Standard (or higher) profits

"Specials" put you in the RED

Special design | Special drawings | Special purchase | Special (delayed) delivery | Special stock

Special tools | Special production | Special bookkeeping | Special costs (higher) | Special profits (lower)

Knurled Socket Head Cap Screw | Flat Head Socket Cap Screw | Self-Locking Knurled Point Socket Set Screw | Knurled Socket Head Shoulder Screw | Fully-Formed Pressure Plug | Precision-Ground Dowel Pin

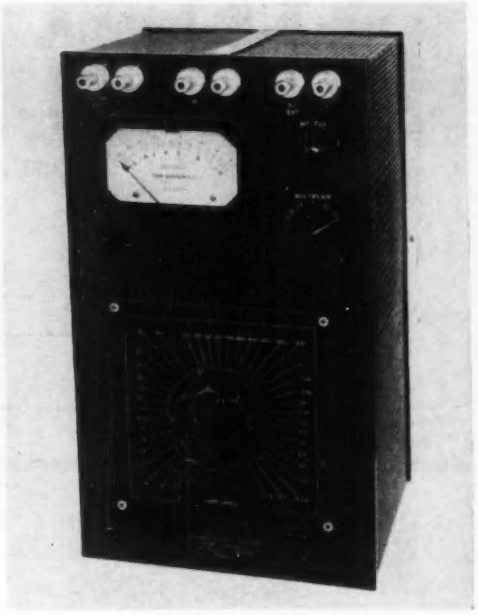
STANDARD recommends "Standards"

SPS

STANDARD PRESSED STEEL CO.

JENKINTOWN 31 PENNSYLVANIA

Power Meter Readability and Range Improved



Output power meters measure the actual power delivered by an audio signal system to a given load. However, because of the characteristics of the circuit, they are suited to other applications such as determination of characteristic impedance of an a-c source, effects of load variation on a signal system, transmission line equalization measurements, measurement of insertion loss in multi-channel mixer and other complex circuits, filter and transformer measurements, and radio receiver measurements.

Its line of these meters has been increased by the Daven Co. to include another which covers the range from 0.1 mv to 100 w in 0.1 mw steps. To improve readability, a large meter has been installed which is calibrated from 0.01 to 0 w and from -10 to $+10$ db. Zero level is 1 mw. The meter multiplier extends the range from 0.01 to 100 times scale reading. To extend the power range below 0.1 mw, provision has been made for use of a calibrated external amplifier. Moreover, an oscilloscope can be connected in a circuit to observe the wave form of the signal. This model has 40 selected impedances between 2.5 and 200,000 ohms, and the accuracy is ± 2 percent over the frequency range from 30 to 10,000 cycles. The instrument is mounted on a black engraved metal panel and is enclosed in a ventilated metal case. Binding posts are provided on the panel for input, amplifier and oscilloscope connections.

Daven Co., 191 Central Ave., Newark 4, N. J.

Circle No. 17 on Reader Service Card

Chrome Plating Made Simple and Quick

The low coefficient of friction and the hardness that chrome plating can impart to machine tool accessories and component parts to reduce their wear has not been utilized to its full extent in the past, it is said, because the equipment and skilled personnel required for chrome plating have made this process a major investment. Recently, however, there has been developed a plating unit and a plating solution that will provide production industries with facilities for chrome plating metal surfaces up to 10 sq in. at a current density of 2 amp per sq in. The process requires no prior plating experience, no complex preparation, and no cumbersome equipment.

Compact and portable, the plating unit is powered by a dry disk, power pack selenium rectifier and includes the tank, a heavy duty rheostat, timer, ammeter and reversing switch for stripping action. The chrome deposit can be controlled to tolerances of less than 0.0001 in.

The plating solution is a controlled formula available in concentrated form ready for dilution with water. It is used at room temperature and requires no heating. It delivers a chrome plate that follows the contours of the base metal at a constant rate of depositing of 0.002 in. per hour. On this basis, for example, the time required to chrome plate cutting tools and wear parts is $1\frac{1}{2}$ minutes.

Ward Leonard Electric Co., Mount Vernon, N. Y.

Circle No. 18 on Reader Service Card

CONTINUED ON PAGE 192

Customer Reports:

ONLY 250 LBS. REJECTED OUT OF 2,000,000 WITH ASARCO CONTINUOUS CAST BRONZES!

A prominent manufacturer of railroad equipment reports: Only 250 lbs. of Asarco Continuous Cast bronze rejected out of a 2,000,000 lb. experience . . . better properties than other bronzes . . . scrap losses practically eliminated.

There are virtually no rejects when you use Continuous Cast bronzes. The unique Asarco casting process gives you bronze rods, tubes and shapes with fatigue and impact characteristics up to 100% better than those of sand cast bronzes . . . with better tensile strengths, yield strengths and hardnesses . . . with no porosity, no hard or soft spots. Asarco Continuous Cast bronzes are ideal for use on automatic screw machines.

You can get Continuous Cast bronzes made to order in a wide variety of alloys . . . in standard lengths of 12′ . . . lengths 5′ to 12′ on request . . . lengths 12′ to 20′ on special arrangement.

216 sizes of the standard Asarcon 773 bronze (SAE 660) are stocked in 105″ lengths for convenience at warehouses in principal cities across the country. Distributors will cut the warehouse stock to suit your specific requirement . . . *long or short.*

For more data see your Asarco distributor, or send the coupon for a 12-page color catalog that contains complete technical data.

ASARCO
CONTINUOUS-CAST
RODS · TUBES · SHAPES
®

West Coast Sales Agent:
KINGWELL BROS. LTD., 444 Natoma Street, San Francisco, Calif.

American Smelting and Refining Company
OFFICES: Perth Amboy Plant, Barber, New Jersey
Whiting, Indiana

American Smelting and Refining Company
Perth Amboy Plant, Barber, New Jersey

Please send me a free copy of the new 12-page catalog "ASARCO Continuous-Cast Copper Alloys."

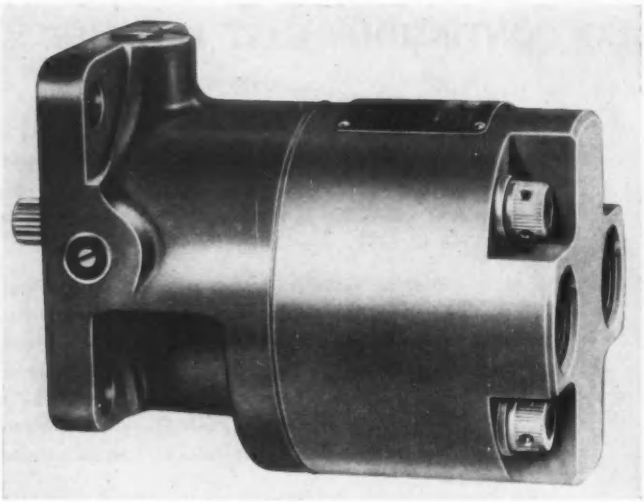
Name.....Title.....

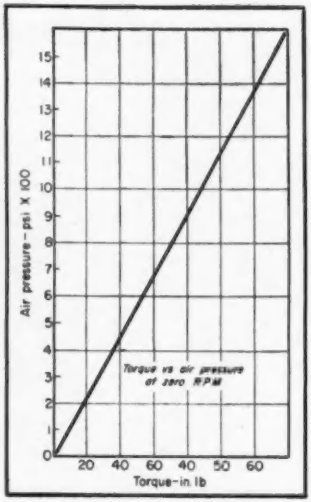
Company.....

Address.....

City.....Zone.....State.....

Motor Serves As Emergency Aircraft Actuator





In case the electrical canopy actuator is inoperative, this pneumatic motor is used to open the canopy of a fighter aircraft. However, it is believed to be adaptable to other actuator applications requiring rotary motion of the prime mover.

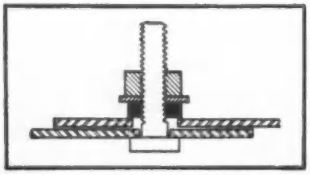
The motor is a gear type of 0.310 cu in. displacement rated for 1,500 psi air pressure and tested for a running torque of 25 in-lb under conditions of limited energy taken from a 52 cu in tank precharged with compressed air at 1,000 psi. Speed may be varied by controlling the air feed to the motor. Torque is proportioned to input air pressure.

A light weight of 1.5 lb is maintained through the use of precision parts in an aluminum body. The only moving parts are the two impeller gears which run on needle bearings. The motor is reversible. Its drive shaft has splined connectors and uses no shaft seal or packing. Escape plugs vent air leakage away from the drive shaft. The mounting flange takes an adapter for special installations.

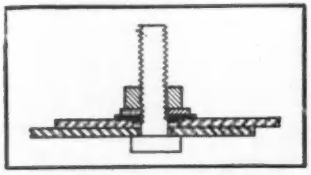
Lear, Inc., Elyria, Ohio

Circle No. 19 on Reader Service Card

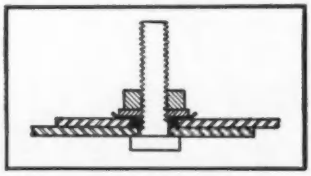
Washer Seals Out Air, Dust and Water and Reduces Squeaks



SEALER WASHER to seal bolts and similar parts is a small thick washer, a more effective seal than a thin one which would exude out around the metal washer. Made of an elastic compound, it comes in standard sizes with inside dimensions such that the washer fits snugly over the bolt.



AS THE TORQUE ON THE BOLT is increased, the washer material is forced into the annular space between the bolt and the rim of the hole to effect a water tight seal. Besides its sealing qualities, it has strong adherence to faying surfaces. This is effective, it is said, in reducing squeaks and rattles.



BOLT has been tightened to the required pressure. The washer material fills the annular space and is forced out around the edge of the metal washer. For ease of handling, the washers are furnished with a tissue paper on their face. This is absorbed under pressure of assembling the screw, nut and washers.

Presstite Engineering Co., 39th & Chouteau Ave., St. Louis 10, Mo.

Circle No. 20 on Reader Service Card

CONTINUED ON PAGE 194

High Man on the Totem Pole

From the origin of Twin Disc Clutches and Hydraulic Drives on the *drafting board* . . . into all stages of *manufacture* . . . prime consideration is given to the ultimate requirement of trouble-free service in the field.

All are rated conservatively to further assure minimum maintenance requirements.

But when downtime does become necessary, the man with the wrench in his hand can devote it to *repair* time and not *hunt-and-wait* time for replacement parts . . because Twin Disc maintains *seven* factory-branch parts stations, plus 56 well-stocked and strategically located parts depots.

That's why, to be sure of performance—*and service*—always specify Twin Disc Clutches and Hydraulic Drives.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

Clutches & Hydraulic Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

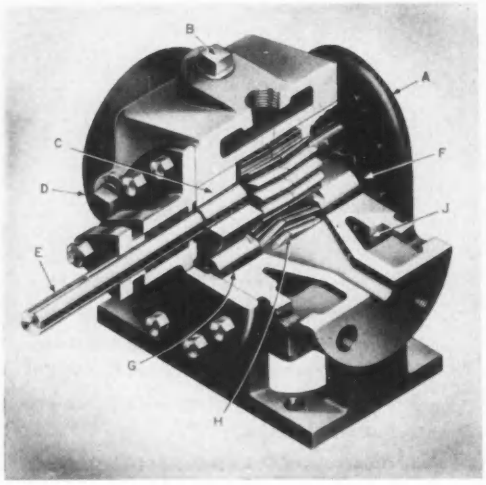
BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

Steam Jacketed Pump Handles Viscous Liquids

For handling viscous liquids such as hot road oils at high temperature there is being offered a herringbone gear pump with a steam jacket that completely covers the internal parts and thereby, it is said, insures even thermal distribution. The inlet, outlet, and cover flanges are cast integral with the pump base to minimize housing distortion due to pipe line strain or misalignment.

The pump comes in capacities to 1,000 gpm and pressures to 500 psi for sizes from ½ to 8 in. Pumps of 1 in. pipe size and above are fitted with Series 30 flanges although tapped connections can be furnished if necessary.

Schutte and Koerting Co., 12th & Thompson Sts., Philadelphia, Penna.



A DOWEL PINS and line up are not required as bearings are located in the housing bore.

B BY-PASS PIPE TAPS on suction and discharge permit installation of by-pass line to handle full pump capacity.

C BEARINGS are phosphor bronze bushings in phosphor bronze or Meehanite B shells and contain relief pockets to prevent trapping of that portion of liquid forced through the bearings from the discharge to suction end.

D STEAM CONNECTIONS are accessible and permit piping arrangements to be varied.

E SHAFT of ground finished alloy steel is of ample size to withstand shock overloads.

F EQUALIZING CHANNEL in the cover plates dissipates pressure on stuffing box.

G STRAIGHT BORE HOUSING minimizes bearing overhang and shaft deflection. Rotor can be removed as unit.

H ROTOR has case hardened gears, press fitted and keyed to shafts to prevent lateral or radial movements. Gear teeth have high pressure angle to reduce slippage.

J STEAM JACKET covers internal parts completely to insure even thermal distribution. Because there are no liquid pockets, drainage is complete.

Circle No. 21 on Reader Service Card

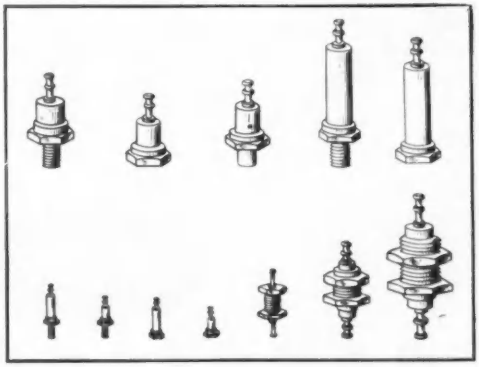
Electronic Hardware Good For All Temperatures

Positive holding and good performance at all temperatures are said to be features of a series of molded insulated miniature terminal lugs, standoffs, and feed throughs now being manufactured in a variety of sizes.

Stand-off types are made of either molded milamine or molded phenolic to government specifications. Molded rather than preformed tubular plastic construction is used to avoid the internal air gaps which act as moisture traps. In addition, it is believed that the method gives positive holding, and units stay solid and tight under normal heat and vibration conditions. All the standoffs are fastened with either a 6/32 screw or nut.

The insulation material used in the feed throughs is phenolic and the metal is brass. Panel thicknesses up to ¼ in. can be accommodated.

In addition to the products described above, U. S. Engineering Co. is introducing a line of potentionmeter shaft locks for both temporary and permanent installations and a group of minature terminal boards. These latter can also be built to customer specifications.



U. S. Engineering Co., 521 Commercial St., Glendale, Calif.

Circle No. 22 on Reader Service Card

CONTINUED ON PAGE 196

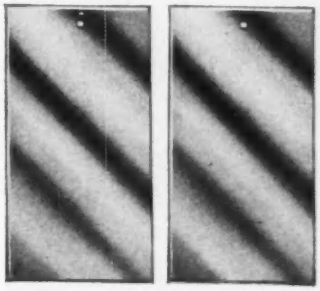
(Advertisement)

Clear Coatings for Zinc and Steel Stand 800 hours' Salt Spray

Increased use of zinc die castings and of zinc-plated steel to replace unavailable materials, combined with the tight supply of copper, nickel and chromium normally used for plating zinc, has focused attention on surface coatings comparable to plating in service performance. Unbiased laboratory tests show that at least two of the clear finishes in the company's line withstand the exceptionally long period of 800 hours' exposure to salt spray and to weatherometer tests.

Effectively protect zinc

These tests demonstrate that DULAC Clear Universal Lacquer #462 and CODUR Clear Synthetic Y743 provide completely satisfactory protection on zinc, zinc plated steel and steel. Even after the unusually severe tests to which these finishes were subjected, there was no indication whatever either of failure of the coating or of discoloration of the zinc.

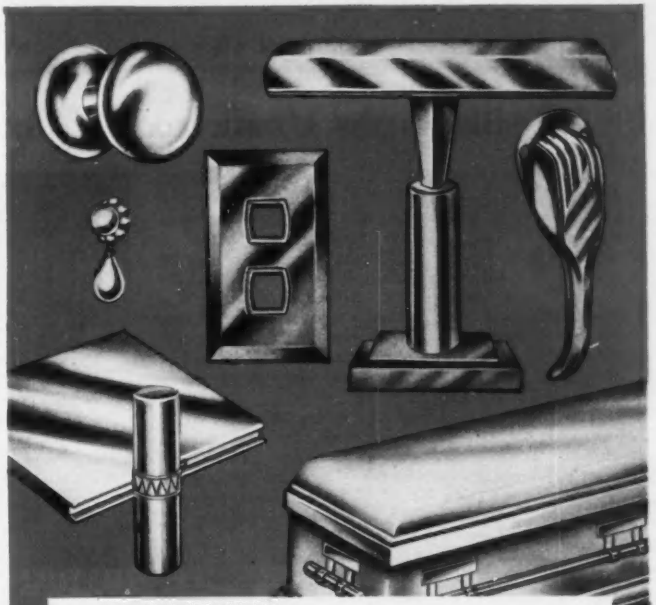


(Left) A zinc-plated steel panel newly coated with DULAC #462. (Right) A similar panel after 800 hours' exposure to salt spray, showing no evidence of attack on the finish.

Adaptability to Drying Schedules

While both finishes give the same performance, DULAC #462 is an air-drying coating, while CODUR Y743 is a baking type. This permits choice of the correct finish to fit into the drying schedules of a particular finishing room.

Technical Data Bulletin #110 on clear finishes is available from Maas & Waldstein Co., 430 Riverside Avenue, Newark, 4, N. J. On request, M & W Technical Service Engineers will discuss specific problems.



NOW! simulate copper, brass and bronze on products like these with

M&W PLATELUSTRE

● Don't let critical metals put a *needless* crimp in your production!

Take zinc or steel—apply a coating of one of the new PLATELUSTRE finishes. You wind up with products and parts that look so much like copper, brass and bronze that *the eye can scarcely tell the difference!*

Whether you have been using now unavailable copper and its alloys for *making* products or for *plating* products, you will find these new M & W finishes *equally* effective in keeping your plant running. There are types for air-drying and baking schedules — pick the one that best fits *your* production requirements.

Let an M & W Technical Service Engineer show you—*right in your own plant*—how easy these PLATELUSTRE coatings are to use, and what striking effects they produce. Or, if you prefer, write for free literature.

PIONEERS IN PRODUCTION

75th ANNIVERSARY 1876

MAAS & WALDSTEIN CO. NEWARK 4, N. J. CHICAGO 12, ILL. LOS ANGELES 34, CAL.

PACIFIC COAST DIVISION: SMITH-DAVIS CO., 10751 VENICE BOULEVARD, LOS ANGELES 34, CAL.

MANUFACTURERS OF INDUSTRIAL FINISHES

Oscillographs Unaffected by Gravity Conditions

As many as 50 channels of separate static or dynamic data can be recorded by the large model of this oscillograph on a single strip of sensitized film or paper 12 in. wide. Moreover, it can be wired for remote operation or operation with other oscillographs for simultaneous recording. The loading operation, it is said, may be accomplished in less than a minute in subdued daylight. The record drive is powered through a variable transmission driven by a governor controlled motor. Coupling between these components is done by a positive action cog belt. A speed adjustment lever on the front panel secures speeds from $\frac{1}{8}$ to 60 in. per second.

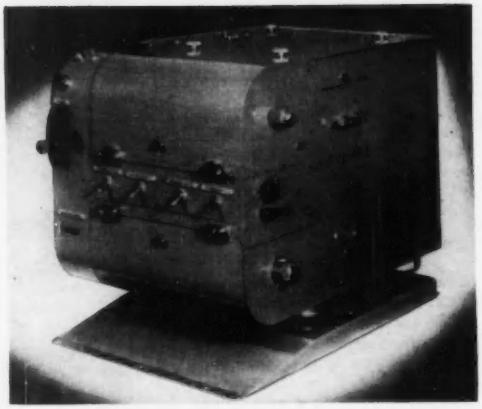
The ground glass screen for viewing the recording is located on the top of the instrument. It is graduated in tenths of an inch. Amplitudes viewed are claimed to be in accurate relation to those being recorded. Adjustment of the rotary scanning motor provide the necessary speed rotation of the multiple-sided mirror for stopping the wave is done by means of a knob on the front.

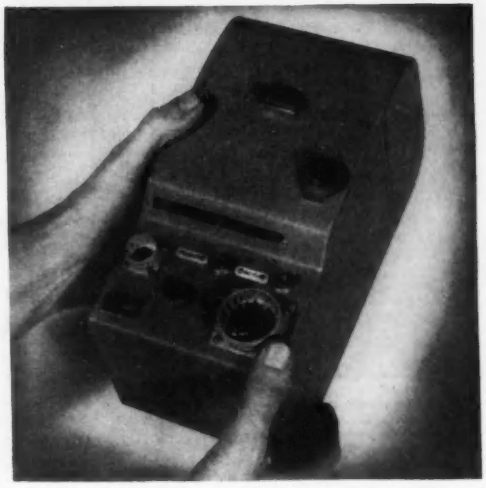
The optical system uses but a single filament lamp for galvanometer excitation. The galvanometers employ a cylindrical mirror. The collumator lens at the recording point is the only one used in the system. Time lines are photographed with the aid of a gas filled flasher type bulb said to be unaffected by gravity conditions encountered in aircraft testing.

To time recorded phenomena, transverse timing lines are photographed on the paper or film at the same time. These lines, which are photographed at intervals of 1/100 sec, are projected by means of a gas-filled glow modulator tube actuated from an electric oscillator, whose frequency is controlled by tuning fork accurate to 1 part in 300,000 per deg Centigrade.

There is also a smaller aircraft model that is said to give efficient performance at more than 25 G's. Up to 18 traces can be recorded. The magazine has a capacity of 50 ft of $3\frac{5}{8}$ in. paper. Paper speed is variable over the $\frac{1}{4}$ to 18 in. per sec range. To preserve the record, where there is a possibility of the oscillograph's destruction, welded steel magazines are available.

The full scale viewing screen located on top of the oscillograph is positioned at the proper angle for trace viewing, and traces are observable in daylight. A precision oscillator drives the horizontal timer. To suit the film speed required, time lines of either 100 per sec or 10 per sec are available. Overall dimensions are 5 x $5\frac{1}{2}$ x $9\frac{15}{16}$ in. and weight is $9\frac{1}{2}$ pounds.





Midwestern Geophysical Lab., 2803 W. 40th St., Tulsa, Okla.

Circle No. 23 on Reader Service Card

GEARED MOTORS of the single reduction type in speeds from 280 to 780 rpm are now available in an enclosed fan-cooled model for dusty atmospheres. Sterling Electric Motors, Inc., Los Angeles, Calif.

WIRE REINFORCED HOSE has strength to withstand pressures of the heaviest pumps in the oil field while retaining flexibility. Transferring from rubber to steel hose in high pressure operations is no longer needed. U. S. Rubber Co., Passaic, N. J.

SILVER CELL BATTERY in a new 5 amp hr model is $\frac{1}{4}$ the weight and $\frac{1}{3}$ the volume of an equivalent lead acid battery. Suited applications where space is limited. Yardney Electric Corp., 105-107 Chambers St., N. Y., N. Y.

TEST LIGHT encased in a plastic housing shines with an easily seen brilliance on any voltage from 3 to 25 v a-c or d-c. Flexible covered leads terminate in spring clips. Uses include low voltage controls such as thermostats and continuity tests on batteries. Industrial Devices, Inc., Edgewater, N. J.

CONTINUED ON PAGE 198

Stop High-Pressure Leaks and Blow-offs

—with ANCHOR Ductile Sleeve Hose Couplings

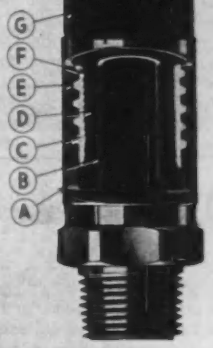
Clamp-type Couplings

2-Piece Re-usable Couplings

Factory application of Anchor's exclusive Ductile Sleeve Coupling is your best insurance against leaks or blow-offs. Our superior grip gives you a plus margin of safety and a minimum time loss due to lay-up of equipment.

Here's how it works (referring to the illustration): Cover stock (G) is removed from the hose by grinding and buffing. Ductile Sleeve (C) is slipped on the end of the hose over the bare wire. Coupling body (A) with steel insert (B) attached is placed in position on the hose. The coupling is then swaged radially on the hose, imbedding the ductile sleeve into the internal grooves of the coupling shell (E) and into the mesh of the wire braid reinforcement (F). This is the exclusive Anchor patented grip.

Some of the applications of Anchor high-pressure flexible oil lines include high-pressure riveting, road machinery, snow plows, coal mining machinery, material handling machinery, machine tool applications, agriculture, railroads, oil field machinery, liquefied petroleum gas, lubrication and various other installations.



NPTF Straight Adapter Unions

45°-90° Adapter Unions

Other styles of related fittings available for piping installations

ANCHOR COUPLING CO. INC.

Factory Libertyville, Illinois • Branch Detroit, Michigan

Send for complete information on Anchor assembled hose units.

Clip coupon to company letter head —and mail TODAY!

ANCHOR COUPLING CO. INC. Dept. PE41
Libertyville, Illinois

I want engineered information on cost-cutting Anchor Ductile Sleeve Hose Couplings. Please send me Bulletin No. 40.

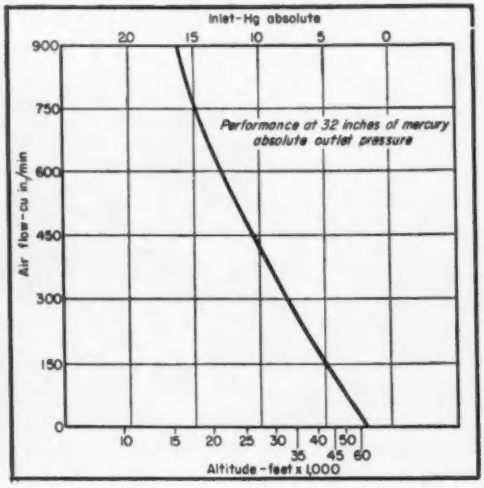
Name _____ Position _____

Company _____

Company Address _____

City _____ ( ) State _____

P-1



Sea Level Pressure Maintained at 50,000 Feet

Oil-free, dry compressed air can be supplied to electronic installations in aircraft by an air compressor designed to maintain 30 in. hg absolute pressure from sea level to 50,000 ft for intermittent operation. Minimum capacity at 50,000 ft is 80 cu in. per min. Sea level capacity is 1,750 cu in. per min. The unit is said to have a service life of 1,000 hr with no decrease in performance.

The pump itself is a positive displacement, rotary vane type. No seals or shaft packing is used. The blades, which with the rotor are the only moving parts, are of a self-lubricated carbon graphite composition that assures positive starting and pumping from —85 F to +160 F.

The pump is equipped with a $\frac{1}{8}$ hp, 115 v a-c, 400 cycle, single phase, 4 amp, 7,200 rpm motor. The pump and motor shaft runs on 3 prelubricated ball bearings.

Lear, Inc., Elyria, Ohio

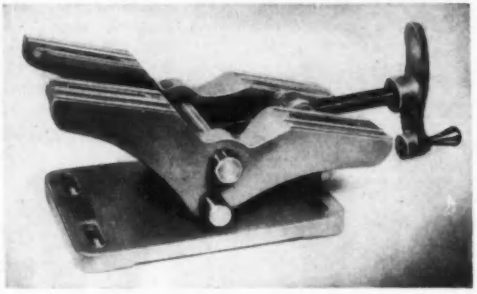
Circle No. 24 on Reader Service Card

Tilting Base Accommodates All Fractional Motors

Fractional hp motors of all types and sizes up to 1 hp can be accommodated by a lightweight tilting motor base that is adjustable in width and length. Its principal use is as a handy, simple speed control when a fractional hp motor is connected with a variable speed pulley. The base also acts as a belt tightener and can be employed for easy belt changing on cone step pulleys.

It is said to have a number of advantages. One is that speed changes can be made while the machine is operating. Another is that the base helps to maintain the correct belt tension and correct alignment. Third, exact speed control is easily obtained by turning a handle screw adjustment.

The tilting motor base weighs 10 lb and is $5\frac{1}{2}$ x 7 in. in size. The fact that it is lightweight and that it can be employed with such a large variety of motors gives it appeal in both shop and laboratory. These features have been achieved only after considerable design development work had been done on the problem.



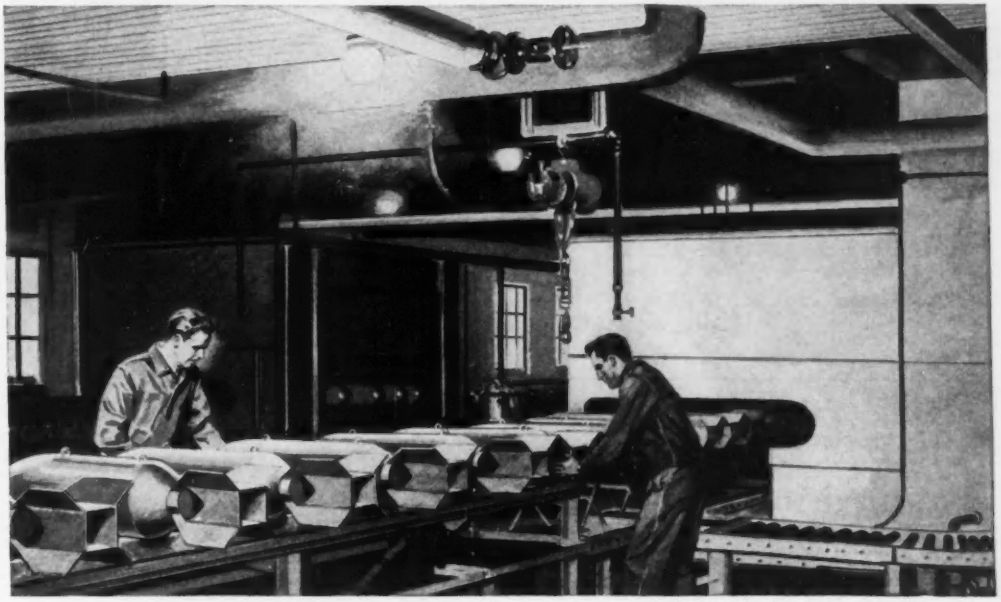
SIMPLE SPEED CONTROL for a fractional horsepower motor driving a variable speed pulley is the principal use for this tilting base. Speed changes can be made while the motor is running.

Lovejoy Flexible Coupling Co., 5226 W. Lake St., Chicago, Ill.

Circle No. 25 on Reader Service Card

CONTINUED ON PAGE 200

Your production lines are defense lines!



Bombs on belt line being fed into booth for spraying.

Consult an Industrial Finishes Specialist

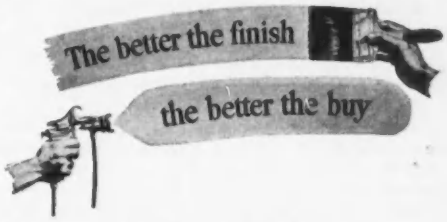
Manufacturing for the armed services—whether it's bombs or tarpaulins, tanks or communications equipment—demands specialized knowledge in the finishing of every vital component.

In the case of bombs, for instance, the inside is likely to be protected with acid-proof finishes to prevent spontaneous combustion between high explosives and uncoated metal. Outside, the bombs, until put into service, must be protected against every conceivable kind of weather condition.

Your Industrial Finishes Specialist knows the latest government specifications, the proper finishes to do the job.

Whether you're manufacturing for the armed services or for civilian markets, it pays to consult an Industrial Finishes Specialist. He's the technically trained sales and production-minded representative of your Industrial Finishes Supplier.

He can help you lower production costs, develop special finishes, meet government specifications, add durability and beauty to your consumer products. Remember—more and more of your customers *start buying with the finish in mind.*



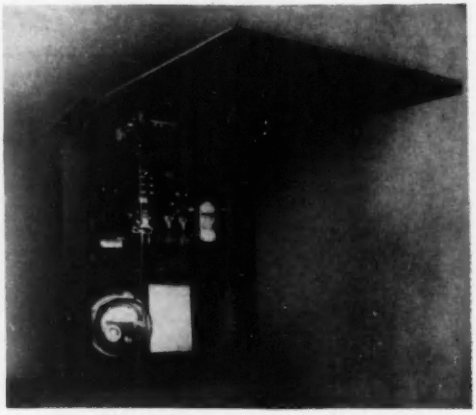
© 1951, National Paint, Varnish and Lacquer Association, Inc., Washington, D. C.

Starter Improves Oil Well Pumping Controls

Designed for application with a single-speed, squirrel-cage motor of the type used in oil well pumping, this combination starter starts, stops and provides the motor with overload, low voltage, short-circuit and lightning protection. Among its components is a time switch that automatically controls the motor for predetermined pumping periods during the day.

Other components include a 3 pole, 650 v lightning arrester and a slam-proof self-indicating handle. The enclosure permits inclusion of optional accessories such as the day omission feature that allows programming of a week's pumping, and the time delay relay for staggered automatic restarting after power failure.

One of its construction features is a top-hinged door that telescopes into the sheet metal cabinet to provide weather-proofing without gaskets, and another is a mechanically interlocked dead front inner door to protect the operator. The product comes in NEMA sizes 1 through 4 in ratings up to 100 hp, 400 v polyphase.



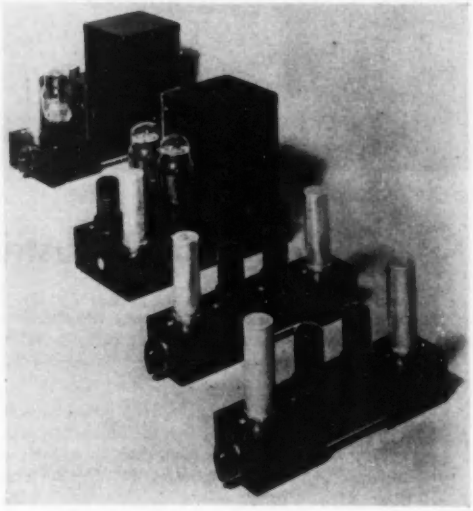
Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh, Penna.

Circle No. 26 on Reader Service Card

Unitized Construction Featured in Amplifiers

A line of amplifiers designed in the form of block units can be assembled quickly and simply, it is said, to form a single, rigid, piece of equipment. Because of the unitized construction, a variety of assemblies can be constructed out of the separate units available, to meet individual requirements. Changes and additions are made as needed. For example, a phonograph amplifier might consist of a unit equalized preamplifier, a unit power amplifier, and a unit power supply. Addition of a unit tone control chassis providing up to 24 db of bass and treble boost and cut is readily accomplished.

All chasses are of a standardized length and of widths which are integral multiples of $2\frac{1}{8}$ in. Small tie plates lock units together to form a single structure for cabinet or rack mounting. The output terminals of one unit are directly adjacent to the input terminals of the next unit. Plate and screen supply and heater power feed directly across, via these terminals, from the power supply through each chassis to the following unit.



Modular Audio Corp., 1546 Second Ave., New York, N. Y.

Circle No. 27 on Reader Service Card

GEARMOTORS of the ventilated type have been added to a line of single phase motors available up to 1 hp and polyphase and d-c motors up to $7\frac{1}{2}$ hp. Janet Mfg. Co., Chicago, Ill.

VIBRATION CONTROL MOUNTING for airborne electronic equipment functions efficiently from —80 F to +250 F over a wide range of loadings. Lord Mfg. Co., Erie, Pa.

MOTOR, in NEMA frame 284, has been added to a line of totally enclosed, nonventilated, squirrel cage, induction motors. Fairbanks, Morse & Co., 600 So. Michigan Ave., Chicago.

—CONTINUED ON PAGE 202

NEED MORE DATA . . .

. . on New Components, Materials, and Parts?

. . on Products Appearing in the Advertising Pages?

WANT COPIES OF . . .

. . the latest catalogs and manufacturers' bulletins?

READER SERVICE

KEEP UP TO DATE

Every month Product Engineering describes in detail the most significant NEW developments in parts, materials, components, and products . . . and lists scores of NEW catalogs and bulletins available from manufacturers. To obtain additional information on these new products and to get copies of any manufacturer's bulletin of interest to you, use the postcards on these pages.

USE THIS CARD

- For further information on products described in the New Components, Materials, and Parts Department, circle the postcard number.
- For additional information on products advertised in this issue, fill in numbers of the pages on which the products are advertised in spaces provided on postcards. Use advertiser's initial if more than one advertisement appears on a page. Write in name if pages are unnumbered.
- For copies of any manufacturers' bulletins described on page 214 and following, circle postcard number.

PRODUCT ENGINEERING: *Not good after 6/1/51*

Please send me more information on the New Parts and copies of the New Bulletins identified by numbers circled below:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120

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COMPANY _____

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Readers' Service Department

PRODUCT ENGINEERING

330 West 42nd Street

New York 18, N. Y.

READER SERVICE

KEEP UP TO DATE

NEW CATALOGS AND BULLETINS

NEW PARTS, MATERIALS, AND COMPONENTS

PRODUCTS APPEARING IN THE ADVERTISING PAGES

Getting ALL the information about ALL of the significant new developments in the design field every month is a tough . . . and time consuming . . . job. To save you time, the editors of Product Engineering screen hundreds of new products each month, select the outstanding ones, and check the manufacturer of each for additional information on construction, operation, and applications prior to describing them on the editorial pages. They scan scores of new catalogs and bulletins, present summaries only of the ones they know will be of interest.

The result is time saved . . . for you. All you have to do to get further information is to fill in the easy to use postcards on these pages. Product Engineering's Reader Service Department will do the rest. Note: Please reserve one of these cards for the engineer who gets the issue after you. He too is interested in new developments.

For new Catalog and Bulletins descriptions turn to Page 218.

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41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
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101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120

Advertising on pages

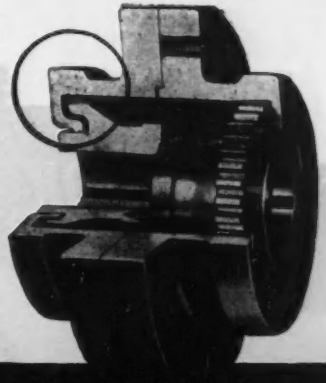
NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____ 4/51

NEED "SPECIAL" COUPLINGS?



Koppers Can Help You Save Money With *Easily Modified*

STANDARD Fast's Couplings

FOOLPROOF DESIGN: Instead of perishable oil seals, Fast's use a permanent metal-to-metal closure. Oil is always maintained at a safe level, whether the Fast's is running or standing still!

LOWEST COST: Fast's Couplings cost less per year because they normally outlast the equipment they connect. Original cost can be divided by 20 years or more. As one user says: *"We've had this Fast's Coupling since 1930 . . . it's apparently going to last forever!"* (Name on request.)

NEW DEVELOPMENTS: Fast's were the first gear-type couplings on the market. And they're first again with new designs developed by Koppers—like the revolutionary new Breaking Pin Coupling now available.

IF YOUR coupling problem looks tough—specify Fast's. Then Koppers' engineers can go to work, study your problem, and in many cases find a special coupling is not needed at all. Instead, these coupling specialists can often modify a *standard* Fast's Coupling and save you important money!

Standard Fast's Couplings can be modified for hundreds of unusual applications. Records kept over the past 31 years prove that Fast's Couplings outlast the equipment they connect. Fast's still maintains its original design, without basic change or sacrifice in size or materials.

Don't take chances. Whether your application calls for special or standard couplings, specify Fast's. For full information and specifications, write for your copy of Fast's free catalog today!

KOPPERS

FAST'S

THE ORIGINAL GEAR-TYPE

Couplings

INDUSTRY'S STANDARD FOR 31 YEARS

Mail COUPON TODAY FOR FREE CATALOG!

KOPPERS CO., INC., *Fast's Coupling Dept.*,
234 Scott St., Baltimore 3, Md.

Gentlemen: Send me Fast's Catalog which gives detailed descriptions, engineering drawings, capacity tables and photographs.

Name.....

Company.....

Address.....

City.....Zone.....State.....

ENGINEERS'
NOTEBOOK

V-Band Couplings simplify Hot Air Valve Installation on Lockheed F-94

Electrically operated hot air valves used on Jet engines demand a joint seal that will withstand high temperatures and pressures. Ideal solution employed on Lockheed F-94 Hydro Air Valve illustrated, is a Marman V-Band Coupling. This lightweight, compact joint easily withstands pressures as high as 400 p.s.i. and temperatures of 450° F. At the same time it is quickly detachable for fast assembly and disassembly—saves weight, space and cost.

Rigid High Strength Connection for Jet Aircraft Fuel Filter

Marman V-Band Couplings are also utilized to connect fuel filters on Lockheed F-80, F-94 and T-33 series. Tested at 150 p.s.i., these connections provide a positive seal under vibration and stress.

Marman V-Band Couplings are usable for all types of flanged joints. Standard types available for wide range of temperature, pressure and strength requirements.

Save Cost and Design Time with Marman
Standard Clamps for Special Applications

FOR INFORMATION WRITE: DEPT. E-4

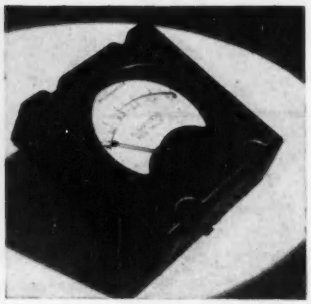
MARMAN PRODUCTS CO. INC.

940 WEST FLORENCE AVENUE
INGLEWOOD, CALIFORNIA

Meter Measures Radioactivity

Radioactivity, which is revealed by radiation detection devices as being present in any area, can now be measured quantitatively by a meter recently produced. The amount of radiation is expressed by this meter in milliroentgens, a roentgen being the basic measuring unit of alpha, gamma, and beta rays which are produced by an x-ray machine, a piece of radium, or an atom bomb explosion.

This instrument is equipped with



either 4, 5 or 6 scales making possible fine readings in all ranges of radiation. The four scale model covers four ranges of radiation: 0 to ½ a milliroentgen; 0 to 5 milliroentgens; 0 to 50 milliroentgens; and 0 to 500 milliroentgens. Setting a switch determines which of the multiple scales will operate and will be visible. This prevents incorrect reading by use of the wrong scale.

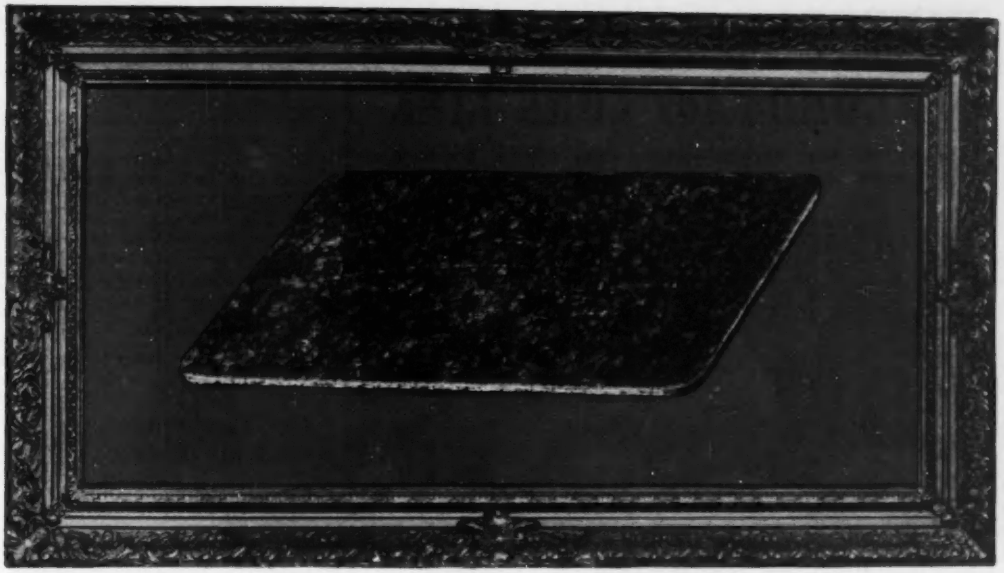
Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

Circle No. 28 on Reader Service Card

Redesigned Capacitors Meet Requirements

To meet more precisely the requirements in the field, Vitramon, Inc., has redesigned its capacitors. The changes have, however, been physical alterations only.

For one thing, the leads have been changed so that they are coaxial with the body of the unit to make the capacitor fully insulated. Moreover, a bead of enamel has been added to isolate the lead terminal from the face of the capacitor body. This permits the capacitor to withstand 500 v from either lead to a metal plate laid against the side of the capacitor. Third, the dia of the leads has been changed so that the lead will withstand 5 lb of axial pull and 2 lb of pull at 90 deg



PORTRAIT OF A 50% SAVING !

This is a picture of a laminate reinforced with Fiberglas* mat.

It matches—even surpasses—the electrical and mechanical properties of laminates reinforced with organic materials . . . *yet it costs as much as 50% less!*

Because the Fiberglas materials used for reinforcement in this new laminate panel resist the destructive action of water, oils, and most chemicals, the laminate is ideal for insulating apparatus which is subject to extreme operating conditions. Electrical properties of this glass-reinforced material are superior. Arc resistance has an ASTM rating of 150 sec. It machines readily and cleanly in production operations where carbide tipped cutting tools are used.

If you make or use electrical apparatus, and want top-flight insulation at rock-bottom cost, consider laminates reinforced with Fiberglas mat.

Sheet stock and molded shapes made of Fiberglas glass-base laminates give superior service for—

COIL WASHERS • TERMINAL BLOCKS
BARRIERS and SHIELDS • SLOT WEDGES
END LAMINATIONS • BASE PLATES
LAYER INSULATION

OWENS-CORNING
FIBERGLAS

IS IN YOUR LIFE...FOR GOOD!

*Fiberglas is the trade-mark (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for a variety of products made of or with glass fibers.

OWENS-CORNING FIBERGLAS CORPORATION
Electrical Sales Division, Dept. 807
16 E. 56th Street, New York 22, N. Y.

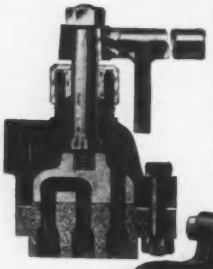
Please give me more information about Fiberglas glass-base laminates.

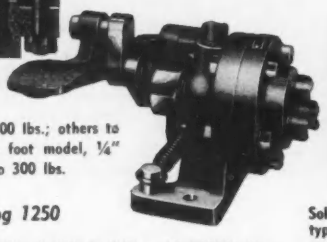
NAME.....
TITLE.....
COMPANY.....
STREET.....
CITY.....ZONE.....STATE.....

NICHOLSON CONTROL VALVES SET

RECORDS for LONG LIFE

In a wide range of plants—steel, metal working, processing, etc.—many Nicholson cylinder control valves have now been in continuous service for over 25 years. Their capacity for long leak-free service is confirmed by repeated installation records showing Nicholson valves actually become tighter with use. This is because their non-corrosive flat discs tend to lap themselves on the seats. For air, gas, oil, steam, water.





Above, lever model, ¼" to 2½", press. to 500 lbs.; others to 5000 lbs. Right, foot model, ¼" to 1½", press. to 300 lbs.

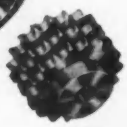
Solenoid and motor types, ⅛" to 2½"; press. to 375 lbs. Many metal combinations.

Catalog 1250

W. H. NICHOLSON & CO. 200 OREGON ST. WILKES-BARRE, PA.

Sales and Engineering Offices in 53 Principal Cities

SPROCKETS are easy to order...



...RIGHT OUT OF THE CATALOG

When the job calls for stock roller chain sprockets —Sewall is as near as your telephone or mailbox. Precision-made Sewall sprockets add life to your chain drives—and they're available in a wide range of sizes. Do you have our catalog?

Prompt quotations on all types of Custom-Made sprockets.

By the Makers of Sewall Gears

NEstor 1381

E. D. SEWALL MANUFACTURING CO.

696 Glendale St. • St. Paul 4, Minnesota

to the axis, subsequently reversed 180 deg.

These capacitors will now retain these specified characteristics over ambient temperature changes from −55 C to 200 C. Formerly this range was −55 C to 100 C. The capacitors will withstand 200 percent of rated voltage for 5 sec. To achieve these design changes, the maximum thickness of the 4 body sizes has increased a few hundredths of an inch. Four new sizes have been added.

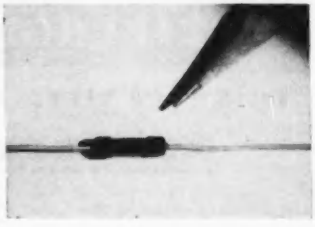
Vitramon, Inc., Stepney, Conn.

Circle No. 29 on Reader Service Card

Low Temperature Coefficient Resistor

High frequency requirements have been met by two types of resistors, the wire wound resistor and the carbon film type resistor. Although the latter possesses numerous advantages compared with the former, not the least of which are smaller size and lower cost, the wire wound resistor has maintained its position in the high frequency field because of its low temperature coefficient of resistance. Now, however, by adding boron to the carbon deposit, the manufacturer has produced a film type resistor which he claims has temperature coefficients comparable with those of wire wound units of the same resistance value.

Carbon film resistors are composed of thin films of microcrystalline carbon formed over the surfaces of ceramic cores. The conducting films of carbon are deposited by the thermal decomposition or pyrolysis of hydrocarbon gases or vapors. The graphite-like crystallites are on the average only one ten millionth of an inch in diameter and half as thick and are so closely and randomly packed together that all resemblance to graphite is lost. Pyrolytic carbon is much harder than carborundum and leaves no smear when rubbed on paper as does graphite. Structural and analytical studies have shown however, that each crystallite is surrounded by a skin or layer of complex hydrocarbons which separates



American Offers FELTS TO ARMED FORCES SPECIFICATIONS

If you have Defense Order Contracts, or subcontracts calling for the use of wool felt, get in touch with American. We can supply you with the felt to meet your specifications.

When writing, please use these felt specification numbers on your contracts.

This information is important, since in recent years there have been changes in Federal specifications for wool felts. American knows and will gladly work closely with you to see that Defense Orders for felt are filled with material that meets the requirements exactly.

Note These Two Specifications

Here are the two most important specifications for wool felt.

Specification No.	Title
Air Force Contracts	
MIL-F-5656 (Supersedes AN-F-14a) (Identical with S.A.E. Felt Specifications)	Felt Wool
All Other Contracts	
Federal Specification C-F-206 (Identical with S.A.E. Felt Specifications)	Felt Mechanical Roll

American Felt Company

TRADE MARK

GENERAL OFFICES: 25 SUMMER ROAD, GLENVILLE, CONN.

St. Lo[illegible]

Fawick Clutches and Brakes have "performance-proved" their reliability and advantages to the press and metal-working industry.

They have proved that the split-second action of Fawick units produces faster starts and stops, resulting in shorter operating cycles and increased production.

They have proved that the safe, positive action of FAWICK units delivers FULL power and that they contribute greatly to continuous top-efficiency production by the elimination of down-time for adjustment or lubrication.

In addition, operators have their choice of the well-known Fawick "E" Brake, if they prefer an air-applied brake, or the new Fawick "S" Brake if they prefer a spring-applied, air-released brake.

When you consider the additional Fawick advantages of operator safety, machine overload protection (at a selected air pressure), and unequalled low maintenance, your most practical answer to peak production on your machines is FAWICK Airflex Clutches and Brakes.

FAWICK AIRFLEX COMPANY, INC.
9919 CLINTON ROAD • CLEVELAND 11, OHIO

For detailed information on the advantages of FAWICK CLUTCH AND BRAKE UNITS as they apply to your machine problem call or write the Main Office, Cleveland, Ohio, for Bulletin 300.

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

it from its neighbors. This hydrocarbon skin increases the specific resistance and the temperature coefficient of resistance of pyrolytic carbon relative to graphite which, along certain crystal axes, is a good metallic conductor. Decrease in the thickness of this skin or in the total volume it occupies results in a decrease in both the specific resistance and the temperature coefficient of resistance of pyrolytic carbon films.

The film type of resistor is particularly useful at high frequencies, for not only can it be made to have small reactance but it is, in effect, all skin so that there is no increase in resistance at high frequencies due to skin effect. The film is also well cooled through its intimate contact with the core and this makes possible the dissipation of large amounts of power per unit area. Among the other characteristics which the pyrolytic carbon resistor possesses are the tolerances of one percent or better attainable in production, the stability in use, the relatively small and predictable temperature coefficient of resistance, and the low noise level.

Borocarbon films are produced by the pyrolytic co-deposition of boron and carbon from suitable gaseous compounds of these elements. Their temperature coefficient of resistance depend both on film thickness and on boron content. By suitable variation in these, temperature coefficients as small as 20 ppm per deg C can be achieved. Borocarbon resistors of 10 megohm values in half watt sizes with temperature coefficients less than 100 ppm per deg C can be produced, while resistors of 250,000 ohms or lower have temperature coefficients less than 50 ppm per deg C. These values of temperature coefficient are entirely comparable with and, indeed, smaller in many cases than for wire wound units of the same resistance value.

The specific resistance of borocarbon films depends on their boron contents, and by suitable variation in composition, films of very high resistances per square can be produced. Values of 500,000 ohms per square are readily obtained and values in excess of 1,000 megohms per square have been studied. The temperature coefficients of resistance for these high resistance films are larger than for films of lower resistance, but in the extremely high resistance ranges made accessible through use of these films, temperature variations are generally of lesser importance.

The only model in which the borocarbon resistor is at present being produced has a resistance of 300 ohms. It consists of a film of boron and car-

TOP NOTCH CONTACTS FOR CORROSIVE CONDITIONS

High among the advantages of Stackpole Silver Tungsten Contacts is the fact that they stand up well under corrosive atmospheric conditions. Salt air, high humidity, sulfide atmospheres and similar adverse conditions do not affect this material to the extent that they do many other refractory contact materials.

Probably no other contact material does a better job of assuring low contact resistance in continued operation where heavy arcing is present or under closed conditions. Stackpole silver tungsten contacts are made in practically any desired shape or size and in grades specifically "tailored" to your application.

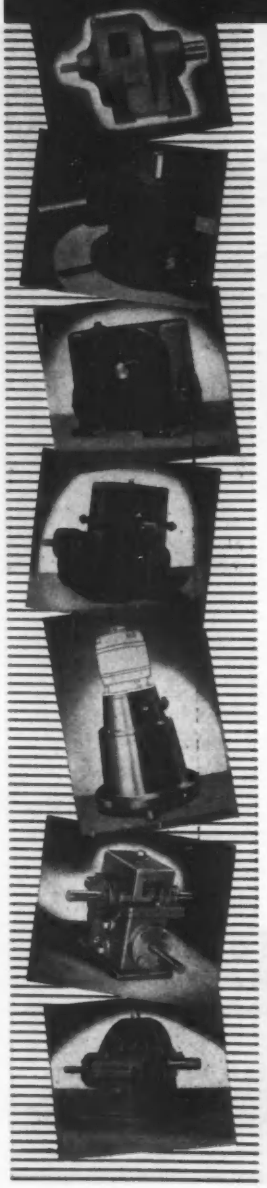
STACKPOLE CARBON COMPANY
HANDY CONTACT DATA **ST. MARYS, PA.**

Stackpole booklet No. 12 contains a wealth of data to help solve your contact problems. Write for your copy today.

ELECTRICAL BRUSHES (All carbon, graphite, metal and composition types) • RARE METAL CONTACTS WELDING RODS, ELECTRODES and PLATES • BRAZING BLOCKS • RHEOSTAT PLATES and DISCS PACKING, PISTON and SEAL RINGS • CARBON REGULATOR DISCS • SINTERED IRON COMPONENTS and many other items.

Shorten the interval between design and assembly line with

WINSMITH Standardization



Huge military and domestic needs place increased emphasis on design speed-ups and production simplification.

This calls for maximum standardization. One way to achieve it, where power transmission problems are involved, is with Winsmith speed reducers. For, no matter how individual the purpose, how specialized the function, how complex the design and production problems, most requirements can be served with standardized Winsmith reducers.

With industry's widest range of standard designs and sizes from fractional to 85 H.P., Winsmith can meet your normal and special demands . . . can help you shorten the interval between machine design and assembly line.

And a Winsmith power transmission engineer in your locality is available for consultation.

DESCRIPTIVE FOLDER, "Save through Standardization," will aid in your selection. Write.

WINFIELD H. SMITH CORPORATION

111 Eaton St.

Springville (Erie County), N. Y.

50th WINSMITH 1901-1951 ANNIVERSARY

WINSMITH SPEED REDUCERS

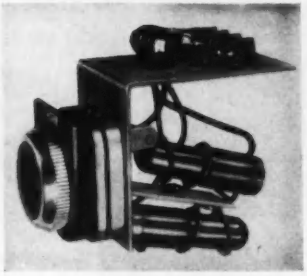
bon ten millionths of an inch thick deposited on a ceramic core. Two coats of lacquer are applied over the film. The core is ¼ in. in dia, 3/16 in. at the caps and 9/16 in. in length.

Bell Telephone Laboratories, 463 West St., New York 14, N. Y.

Circle No. 30 on Reader Service Card

Mercury Switch is Safe In Explosive Locations

Safety in hazardous, explosive locations can be secured with a mercury switch which comes in both a push button model and a selector knob model. The unit consists of a hermetically sealed mercury switch mounted on a level-operated armature. Turning the selector knob or pushing the button inclines the armature and actu-



ates the mercury switch. There is no possibility of any spark because the actuating linkage is mechanical in nature.

Designed for vertical panel mounting, this single pole switch has either double or single throw action. Push button models feature a spring action that returns the switch to original position when finger pressure is released. The selector switch type can, of course, be set in either the "on" or "off" position.

Panalarm Products, Inc., 7212 N. Clark St., Chicago 26, Ill.

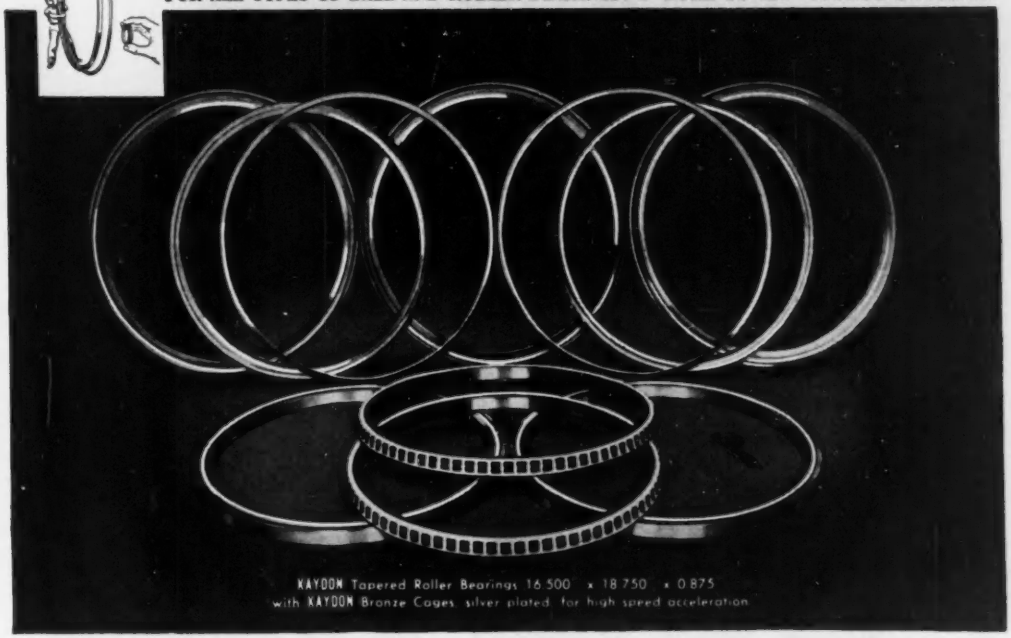
Circle No. 31 on Reader Service Card

Variable Capacitors Offer Tuning Accuracy and Stability

Commercial and government land and marine communications and microwave equipment can be equipped with a piston type variable trimmer capacitator whose low capacities are said to provide accurate and stable electronic adjustments. It delivers a uniform change of capacitance in relation to

Contact KAYDON Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER



KAYDON Tapered Roller Bearings 16.500 x 18.750 x 0.875
with KAYDON Bronze Cages silver plated for high speed acceleration

Safe Way to Reduce Weight

Look again at this thin section bearing. KAYDON bearings like these, designed with very thin section, are a boon to design engineers who recognize weight-reduction and greater precision as prime problems today.

KAYDON Thin-Section Tapered Roller, Straight Roller, and Ball Bearings are helping solve such problems. All types can be made unusually light in weight, and permit much more compact machine design.

Unique high precision techniques that hold to closest tolerances in bearings as large as 120 inches outside diameter, assure consistent accuracy in all types and sizes of KAYDON bearings and needle rollers.

* * *

For your precision bearing requirements, contact KAYDON of Muskegon.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust
• Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

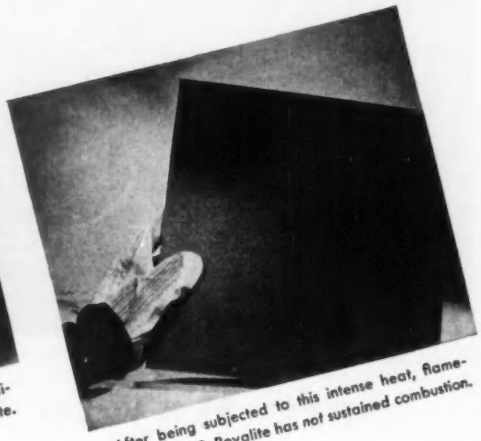
PRECISION BALL AND ROLLER BEARINGS

HERE AT LAST

A Flame-resistant Thermoplastic

U. S. ROYALITE the sensation of the plastics field

A blow torch that develops tremendous heat is directed on a square of flame-resistant U. S. Royalite.



After being subjected to this intense heat, flame-resistant U. S. Royalite has not sustained combustion.

If you've been waiting for a flame-resistant plastic, it's here . . . it's *U. S. Royalite!* This great material makes possible countless new developments in design and construction, lets plastic fabricators do things never possible before.

Royalite is versatile, light in weight, and more efficient than the materials it replaces. This great thermoplastic can be sawed, sheared, sanded, punched, nailed, bolted, riveted, sewed and cemented. It can be formed on standard equipment with conventional techniques.

ROYALITE IS

- ★ Flame-resistant
- ★ Lightweight
- ★ Unbreakable, non-splintering
- ★ Non-warping, non-corrosive
- ★ Waterproof, stainproof
- ★ Not affected by oils, most acids, alkalies
- ★ Comes in different colors

SEE NEXT PAGE FOR LIST OF U. S. ROYALITE FABRICATORS

u.s. Royalite
STANDARD OR FLAME RESISTANT

UNITED STATES RUBBER COMPANY

2638 NORTH PULASKI ROAD • CHICAGO 39, ILLINOIS

u.s. Royalite

CONSULT THESE EXPERIENCED FABRICATORS OF ROYALITE

CALIFORNIA
Artisan Engineering & Mfg. Co., Inc., 5037 W. Jefferson Blvd., Los Angeles 16
Horace L. Blackman Co., 287 So. Robertson Blvd., Beverly Hills
General Plastics Corp., 723 W. Broadway, Glendale 4
Engineering Plastics Co., 1475 El Mirador Dr., Pasadena 3
National Plastics Industries, 425 Divisadero St., San Francisco
Swedlow Plastics Co., 5527 District Blvd., Los Angeles 22
Technical Reproductions, 5526 Cleon St., N. Hollywood

COLORADO
Pikes Peak Plastic, 5 W. Cucharras St., Colorado Springs
Plasticraft Co., 2806 N. Speer Blvd., Denver

CONNECTICUT
Colt's Mfg., Hartford 15

FLORIDA
Plastics Design & Mfg. Co., Box 61, Tallahassee

GEORGIA
Gladwin Plastics, 542 Courtland St., N.E., Atlanta

ILLINOIS
Arrem Plastic, 1539 N. Throop St., Chicago 22
Associated Plastics Fabricators, 164 N. May St., Chicago 7
J. B. Carroll Company, Corner Carroll and Albany Avenues, Chicago
Cortland Industries, Inc., 4545 W. Cortland St., Chicago 39
Neo Products Co., 2534-38 S. Kedzie Ave., Chicago 23
O-Lin Products, 3755 Kedzie Avenue, Chicago 18
Precision Plastic Products Inc., 628 W. Lake St., Chicago 6

INDIANA
General Plastics Corp., 1400 N. Washington, Marion

MARYLAND
Fawn Plastics Co., 2902 Hamilton Ave., Baltimore 14

MICHIGAN
Cadillac Plastic Co., 651 W. Baltimore, Detroit 2
Imperial Industries, 4435 Walker Ave., Wayne
Klise Mfg. Co., 50 Cottage Grove S.W., Grand Rapids 2
Reynolds Plastics, Inc., 3445 W. Forth St., Detroit
Fabri-Kal, 242 East Kalamazoo Avenue, Kalamazoo
Woodall Industries Inc., 7565 E. McNichols Rd., Detroit 34

MINNESOTA
T. O. Plastics, 58th & Longfellow, Minneapolis
Plastics, Inc., Chestnut & Ryan Sts., St. Paul 2

MISSOURI
Regal Plastics Co., 710 Main St., Kansas City

NEBRASKA
Omaha Plastics Co., 1470 S. 16th St., Omaha 9

NEW JERSEY
Sillcocks-Miller Co., 10 W. Parker Ave., Maplewood
Stokes Molded Products, Inc., Taylor St. at Webster, Trenton 4
Thermacote Co., 320 Jefferson St., Newark 5
Van Beek Industries, 23 Park St., Orange

NEW YORK
Bassons Molded Products, 1424 W. Farms Rd., New York 60
Curbell Inc., 1700 Elmwood Ave., Buffalo 7
Dual Fabricators Corp., 808 Driggs Ave., Brooklyn 11
Dura Plastics Inc., 1 W. 34th St., New York 1
Durable Formed Products, Inc., 329 Canal St., New York 13
Mastercraft Plastics Co., Inc., 95-32 150th St., Jamaica 4
Steiner Plastics Mfg. Co., 47-30 33rd St., Long Island City 1

OHIO
Fabri-Form Co., Box 36, Cambridge
The Baxter Company, 15 E. 2nd Street, Cincinnati

PENNSYLVANIA
Halsen Mfg. Co., 5919 Webster St., Philadelphia
Lee Plastics, A and Lippincott St., Philadelphia 34
Pearson-Berlinghof, Inc., 18 North State Street, Newton, Pennsylvania
The Bell Plastics Co., Inc., 600 Heinz Street, Pittsburgh 12

TENNESSEE
Plasti-Line, Inc., Jacksboro & Broadway, Knoxville 18

TEXAS
Plastic Engineering Co., 2101 69th St., Houston 11
Plastic Products of Texas, 3319 Love Field Dr., Dallas

WASHINGTON
K. B. Plastics, Inc., 1817 So. 1st St., Yakima
Mason Plastics Company, 1121 Westlake North, Seattle

WISCONSIN
Midland Plastics Inc., 227 N. Water St., Milwaukee 2

The United States Rubber Company at 2638 North Pulaski Road, Chicago, Illinois, has complete Engineering, Designing, and Styling Departments to assist fabricators on the technique to employ, and in the art of fabricating most efficiently with ROYALITE.

rotation. Smooth, precise settings without backlash or disturbance from severe vibration are made and maintained, and provision has been made to take up thread wear automatically.

Tubular in shape and one inch in length, the capacitor has a single-unit movable electrode and adjustment screw made of an alloy having a low temperature coefficient of expansion. Some of the capacitor's characteristics are as follows: approximately zero temperature coefficient; "Q" rating of over 1,000 at 1 mc; 55 deg C to 100 C operating temperature; and 10,000 megohms insulation resistance.

The three models that are available have the following specifications when measured at 0.1 mc to 1 mc: one has max 0.3 mmf at minimum setting and minimum 3 mmf at max setting; the second has max 0.5 mmf at minimum setting and min 5 mmf at max setting; the third has max 1.5 mmf at minimum setting and minimum 11 mmf at max setting.

JFD Manufacturing Co., 6101–6123 Sixteenth Ave., Brooklyn, N. Y.

Circle No. 32 on Reader Service Card

Refrigeration Oils Suit High Operating Temperatures

Recent developments in the refrigeration industry, it is said, have brought about a need for new refrigeration oils. These developments are higher operating temperatures and the increased use of hermetically-sealed compressors. The higher operating temperatures result from the more severe conditions under which refrigeration compressors are running. This is true particularly in air-conditioning systems where strict limitations exist on the use of water for cooling purposes.

In compressors having a shaft seal and an external motor drive, motor heat escapes externally and oil temperatures seldom exceed 120 F. Therefore, there is little heat effect on the lubricating oil. If the lubricating oil is affected, the oil can be easily replaced with fresh dehydrated oil.

In hermetically-sealed compressors, however, where the motor and direct shaft drive are operating in the oil-refrigerant mixture, the problem is more complex. The motor heat cannot be liberated externally but is liberated within the compressor shell. Under severe operating conditions, oil temperatures may go as high as 225 F.

Since the original charge of oil in a hermetically-sealed compressor is intended to last for the operating life of

The Swing is to
Durakool
a dependable
10 YEAR SWITCH
Steel-clad with mercury to mercury contacts, the Durakool hydrogen filled switch is performing with sensational dependability.
★ Millions of contacts without a falter
★ Positive "Make and Break" contact action
★ Withstands high temperatures
★ No deterioration in storage
★ Seven new models—1 to 65 amperes
★ Smaller in size, increased capacity
Send for BULLETIN 525
Steel Durakool
MERCURY SWITCHES
See Telephone Directory for Local Distributor or write
Durakool, Inc.
Elkhart, Indiana

O-RINGS
by INJECTION MOLDING
Dependable Hydraulic Seals
Minnesota O-Rings function in air or gas systems as well as in hydraulic systems. Air cylinders . . . hydraulic valves . . . hoisting mechanisms . . . water pumps . . . bottling machines . . . refrigerators . . . motors . . . lubricators . . . are a few of their uses. Minnesota's exclusive injection process makes possible very close dimensions, uniformity in mass production and downright economy. We use special compounds of synthetic rubber to meet your exact requirements. Let us make a quotation on your next hydraulic packing installation.
Manufacturers of all types of small rubber parts
Write for O-Ring Catalog
Diagram shows typical installations
MINNESOTA RUBBER & GASKET CO.
3634 WOODDALE AVE.
MINNEAPOLIS 16, MINN.

the equipment, a minimum of ten years, it must function properly even when operating temperatures are high. An ordinary refrigeration oil under such severe conditions will oxidize and form gums and varnish necessitating removal of the oil from the system. Moreover, in hermetically-sealed compressors changing the oil charge is, of course, difficult and involves a great deal of time and expense.

To meet the need for refrigeration oils that will withstand higher temperatures, there has been developed paraffinic-type oils containing an oxidation inhibitor to make them more stable thermally. They are fortified to prevent the formation of guns and varnish, and they will provide lubrication, without breakdown, for as long as the equipment is in use. Therefore, expensive shutdowns for oil changes are not necessary.

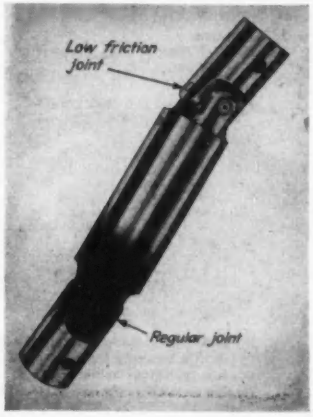
Sun Oil Co., 1608 Walnut St., Philadelphia, Pa.

Circle No. 33 on Reader Service Card

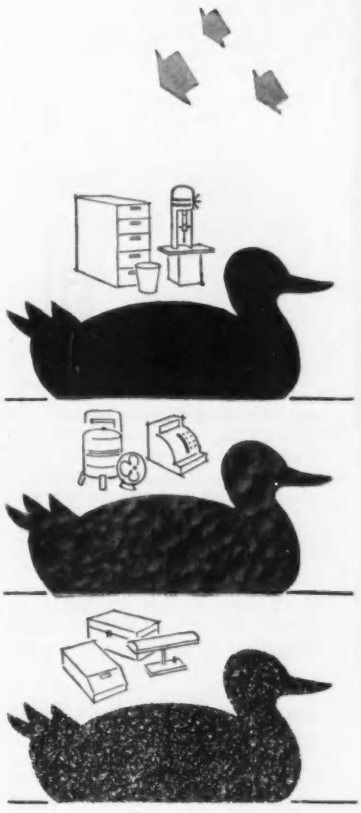
Universal Joint Dissipates Friction Heat Rapidly

For industrial applications where joint friction heat or kinetic energy must be dissipated rapidly, there is a universal joint which is available in single or double joint form, in OD's of 1¾ or larger and solid or bored hubs for round, keyed or splined shafts. The low friction characteristics have resulted from a redesign of the friction block whose bearing surfaces have been reduced and which is provided with constant lubrication.

Also announced is the availability of a ball type universal joint designed for light duty. Its steel forks bear upon a bronze ball, and the pivot



SPRUCE UP "UGLY DUCKLING" PRODUCTS WITH ONE OF THESE THREE S-W "GLAMOUR FINISHES"!



Don't let "hard-to-dress-up" surfaces limit your product's usefulness or sales appeal! One or more of these unique and practical Sherwin-Williams special finishes can give it glamour . . . richness . . . added sales appeal . . . can be adapted easily to your finishing line requirements. Ask for full details on the finishes best adapted to your needs! The Sherwin-Williams Co., General Industrial Division, Cleveland 1, Ohio.

1. DIMENSO "HAMMERED" FINISHES

This exclusive S-W finish is a multichromatic organic that can be applied to any metal or wood surface with a special gun that sprays two colors in a single operation. *Dimenso* bakes quickly to a tough, smooth, durable film of exceptional brilliance. It imparts deep, lasting color, full of life and sparkle and with infinite shadings of tone. It gives realistic, 3-dimensional hammered and spot effects in toned or diffused patterns.

2. DIMENSO ONE-COAT METALLIC

Dimenso One-Coat Metallic offers a high-quality hammered finish at moderate cost with standard spray equipment and a single material. It produces a striking, deep-toned hammer pattern and air dries or bakes to a tough, durable film. By a slight change in method, it is possible to produce an opalescent finish in addition to the hammer finish with identical film characteristics. Available in Silver, Blue, Green and Tan.

3. KEM ART METAL

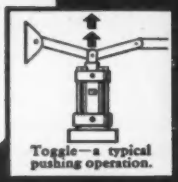
With this line of durable and distinctive nonmetallic wrinkle finishes, highly decorative effects are possible on a wide variety of products. These finishes are applied with conventional spray equipment and fit into any baking schedules, including extremely fast infrared. The film looks thick and tough—actually is—but, at the same time, it has a velvety appearance which is appealing and restful.

SHERWIN-WILLIAMS
INDUSTRIAL FINISHES

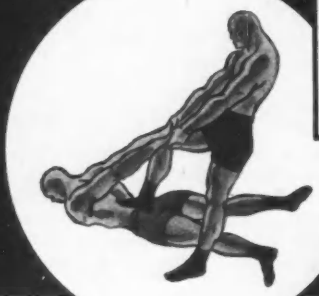
Rasslin' with HIGH COSTS?

SAVE on "MUSCLE JOBS"

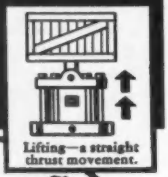
with T-J CYLINDERS



Toggle—a typical pushing operation.



Pulling—as shown in 1st class lever.



Lifting—a straight thrust movement.

Air or hydraulic power—applied by T-J Cylinders—gets an amazing lot of tough jobs done for industry . . . *faster, more efficiently,* and *at lower cost!* Check your plant operations and machines *now* — make a note of mechanical movements that can be simplified and speeded up with T-J Cylinders! Designed for a wide range of pushing, pulling, lifting, clamping or control jobs . . . 100 lb. or 50,000 lb. Many standard sizes and styles . . . both cushioned and non-cushioned types . . . precision-built, dependable. Write for additional information. The Tomkins-Johnson Co., Jackson, Mich.

35 YEARS EXPERIENCE (T-J)

TOMKINS-JOHNSON

RIVETORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHORS

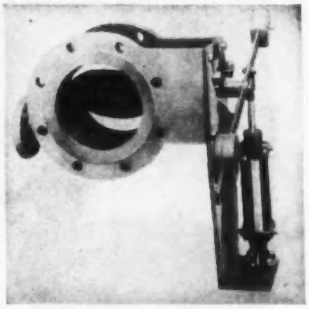
bearing pins are heat treated and centerless ground. This joint comes in 4 sizes from ¾ to 1¼ in. in single or double joint form with solid or bored hubs.

Curtis Universal Joint Co., Inc., Springfield 7, Mass.

Circle No. 34 on Reader Service Card

Off Center Valve Simplifies Steam Control

An off center relief valve of the disk type has been developed which, it is claimed, simplifies the control of 15 psig saturated steam that has low pressure drop. A double crank arm with adjustable weights facilitates accurate setting. The cylinder is not an actuator but a dash pot. The valve



has American Standard raised face flanges, and a flanged outlet is provided for overload relief.

The valves are available in several sizes and for pressures greater than 15 psig. They may also be used in air, gas, liquid and semi-solid service for control and shut off of volume and pressure.

R. S. Products Corp., 4600 Germantown Ave., Philadelphia 44, Pa.

Circle No. 35 on Reader Service Card

Sensitive Double Pole Relay Is Tiny

Claimed to be one of the smallest of hermetically sealed relays, this unit measures 1 in. square by 1¾ in. high, exclusive of the terminals. It can be furnished with a second pole on the switch structure, to provide any switch combination up to double pole, double throw.

The sensitivity of the relay is approximately 40 mw, and it can withstand better than 10 g vibration at frequencies in excess of 60 cps. When 2 to 1 margins for operate and release

A Practical Application of Gates SPECIALIZED Research

A High-Speed Traveling Track Used to Test Aircraft Landing Gear...

V-Belt Drive Designed by Gates Engineers

- ***Track Traveling Speed of 120 to 180 miles per hour—***
- ***Massive Weight to be Accelerated Quickly***
- ***Terrific Torque upon Deceleration***

A large Aircraft Manufacturer planned to test aircraft landing gear by dropping the gear onto a track that would travel at airplane landing speeds of 120 to 180 miles per hour. The landing gear would be loaded with weight to equal that of fully loaded aircraft.

Clearly, the shock impact of the loaded gear, its huge wheels motionless, dropping onto the rapidly moving track, would be very great. As the landing gear hits the track, power to the motor is disconnected, permitting the track to travel on its own momentum. To accelerate the huge wheels and slow down the track requires fully 7600 pound feet of torque. Then the drive must bring the massive track mechanism back up to speed in a minimum of time to be ready for the next test.

It was not by accident that Gates Engineers had complete data—*all worked out in advance*—covering the specifications of a V-Belt Drive that has very competently handled this most exacting assignment.

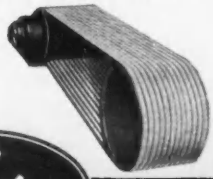
This *pre-solution* of Drive design is possible only because Gates operates the largest V-Belt testing Laboratories in the world. Here, Gates runs an *average* of 32,000 hours of testing *every week* on V-Belts alone! (32,000 hours is equivalent to five years of life for one belt.)

And the real value to *you* of such exhaustive testing is this:—all *results* of these tests are immediately reduced by Gates Application Engineers to *usable data* for the design of V-Belt drives from which *any task whatever* may be required.

Such intensively SPECIALIZED Research has naturally given Gates Engineers a most advanced knowledge of V-Belts and V-Belt Drive Design—and the benefit of this advanced knowledge and experience is available to *you, right in your own plant, any time you want it!*

Whether you have a difficult drive to design—whether some V-Belt drive in your plant is giving trouble—or whether you merely want to know what size and construction of V-Belts will give the most efficient and the lowest cost service on a particular drive—you have only to phone a Gates Engineer near you in all industrial centers.

Just look in your phone book under "Gates Rubber." A Gates Engineer will come to you promptly—and he will put at your service the full benefits of Gates unrivaled V-Belt knowledge and experience *without the slightest obligation!*



ENG-511

Gates VULCO ROPE DRIVES
Engineering Offices and Jobber Stocks IN ALL INDUSTRIAL CENTERS of the U. S. and 71 Foreign Countries

THE GATES RUBBER COMPANY
DENVER, U. S. A.
The World's Largest Makers of V-Belts

O & S BEARINGS
NON-METALLIC • SELF LUBRICATING

Make it Easy to Control . . . "The Tractor that Leaves no Tracks!"

"CATERPILLAR" D2 Prevents Erosion
Unlike wheels, the D2's broad tracks make no gully-breeding ruts; no depressed strips. After harrowing, the D2 has left no tracks.

The D2 is a rugged, efficient, dependable machine because "Caterpillar" Engineers know a quality product depends on quality parts. O & S Bearings and Bushings are typical of the high quality equipment that assures D2 owners long, trouble-free service.

On "Caterpillar" products O & S "Neveroil" Bearings and bushings are used to provide smooth, easy handling of controls, brake levers and linkage located where lubrication is difficult and often impossible.

WRITE TODAY FOR BULLETIN 251 OR SEND PRINTS AND DETAILS

Our 38th Year Manufacturing Original Equipment

NeverOil SINCE 1913
O & S BEARING CO.
303 SOUTH LIVERNOIS • DETROIT 7, MICHIGAN

current are provided, the new miniature relay can be used under conditions of sustained acceleration as high as 50 g.

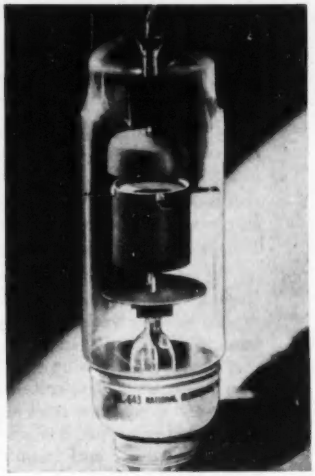
The switch structure is coupled to the armature in such a way that contact wear scarcely changes pull-on and drop-out points. Under most operating conditions, the individual switches close without bounce.

Sigma Instruments, Inc., 56 Ceylon St., Boston 21, Mass.

Circle No. 36 on Reader Service Card

Rectifier Tube for Application to 200 VD-C

Industrial power rectifier needs up to 200 v d-c can be met by a recently introduced mercury-vapor filled recti-

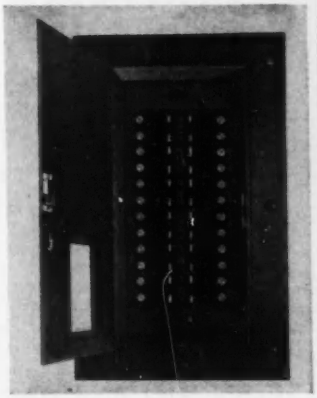


Max d-c output, amp	15
Max instantaneous output, amp	90
Max time of averaging anode current, sec	15
Max peak inverse voltage, v	700
Filament voltage, v	2.5
Filament current, amp	23±2
Filament heating time, sec	120
Typical arc drop at 45 amp peak v	10
Typical anode starting voltage, v	13
Max a-c short circuit current, amp	750
Condensed mercury temp limits, 700 v peak inverse, deg C	+35 — +90
Condensed mercury temp limits, 500 v peak inverse, deg C	+35 — +100
Temp rise, condensed mercury above ambient, no load, deg C	35
Temp rise, condensed mercury above ambient, full load, deg C	50

fier tube. It is said to have high voltage characteristics, high overload capacity and long life.

National Electronics, Inc., Geneva, Ill.

Circle No. 37 on Reader Service Card



Panelboards For A-c Or D-c Applications

These panelboards, which are available from 4 to 40 circuits for use on either a-c or d-c applications, provide plug fusible branches with toggle switches for lighting and appliance branch circuit control.

Construction features embody a 17 in. wide by 4¼ in. deep box with 4 in. wide wiring gutters. Knockouts are provided in the ends and sides. Four branch circuits are contained in one piece, molded bakelite blocks.

Square D Co., P. O. Box 272, Roosevelt Park Annex, Detroit, Mich.

Circle No. 38 on Reader Service Card

Stellite Lengthens Valve Life

A pressure reducing valve which handles working pressures as high as 6,000 psi has been redesigned to make use of Stellite on valve parts that are subject to severe abrasion and corrosion. As a result, the valve is furnished with a Stellite faced main valve and a Stellite faced seat ring. Stellite is believed to outwear steel many times. It has a strength of over 100,000 psi at ordinary temperatures and over 65,000 psi at 1,500 F.

Design changes have also been made in the body of the valve to simplify and strengthen it. The body is of strong steel. The packings are made for high pressure service. Internal metal parts are of chromium plated stainless steel. The pressure on the seat is balanced by a piston above to handle water, oil or air without shock.

Atlas Valve Co., 282 South St., Newark, N. J.

Circle No. 39 on Reader Service Card

The ABC of MST

A LWAYS MAKES POSSIBLE
B ETTER PRODUCTS
C AT LOWER OST

A Quality Product

Michigan
Electric Resistance
WELDED
STEEL
TUBING

ROUND
⅜" to 4" O. D. 9 to 22 ga.
SQUARE-RECTANGULAR
½" to 2" 20 gauge, 1" to 2¾", 14, 16, 18 gauge
Carbon 1010 to 1025

Michigan Tubing has uniform strength, weight, ductility, I. D. and O. D., wall thickness, machinability, and weldability. It can be flanged, expanded, tapered, swaged, beaded, upset, flattened, forged, spun closed, fluted, and rolled. Available in a wide range of sizes, shapes and wall thicknesses, prefabricated by Michigan or formed and machined in your own plant.

Consult us for engineering and technical help in the selection of tubing best suited to your needs.

No Job too Tough

No job is too tough for American workmanship. But the demands of the defense emergency have presented many problems in design simplification to reduce costly production delays. Electric resistance welded steel tubing, as manufactured by Michigan, is a simple and economical answer to many such problems.

During World War II we were among the foremost suppliers of tubing for widely different defense uses, such as incendiary bomb casings, jeeps, trucks, and guns. Our manufacturing skill in the production of tubing for these and hundreds of other applications is at your disposal.

No matter what your manufacturing requirements are, for defense or for products used in home, office, or plant, our engineers are ready to suggest design improvements for faster production at less cost by the use of Michigan tubing.

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CATALOGS and BULLETINS

(40) ALUMINUM COATED STEEL—Armco Steel Corp. Booklet, 24 pp. Describes heat and corrosion resistant properties and heat reflectivity of an aluminum clad steel. Photographs show applications. Included are mechanical, forming and welding data.

(41) THIN STAINLESS STEEL—Armco Steel Corp. Folder, 4 pp. Gives mechanical properties of a stainless steel that is available in thicknesses from 0.001 to 0.010 inches.

(42) TUBING—Superior Tube Co. Bulletin 32, 4 pp. Outlines the chemical properties of small diameter tubing that is available in a variety of steels, nickel alloys and other materials, its tolerances and its fields of applications.

(43) CARRIER AMPLIFIER—Consolidated Engineering Corp. Bulletin, 4 pp. Brings out the features of an instrument that aids in the analysis and evaluation of physical factors involved in product performance.

(44) VINYL COATINGS—Casey & Case Coating Co. Bulletin, 12 pp. Pictures help to indicate applications for these corrosion resistant coatings in such fields as food processing, chemical processing, marine maintenance, petroleum refining and others. A listing of specific properties of the coatings is included.

(45) SPRAY VALVE—Farval Corp. Bulletin 60, 4 pp. Colored diagrammatic views display the operating characteristics of a spray valve that is used to lubricate slide surfaces and open gearing.

(46) HAND AND FOOT VALVES—Ross Operating Valve Co. Installation data and engineering drawings explain the features of a group of ¼ in. and ⅜ in. hand and foot valves for the control of small cylinders and for the pilot operation of master valves.

(47) STRIP CHART RECORDERS—Wheelco Instruments Co. Bulletin C2-2, 4 pp. Diagrams and photographs display the operating system utilized in the strip chart recorder for measuring of temperature, speed, static strain loads and other variables.

(48) STAINLESS STEELS—Carpenter Steel Co. Slide Chart. Provides a

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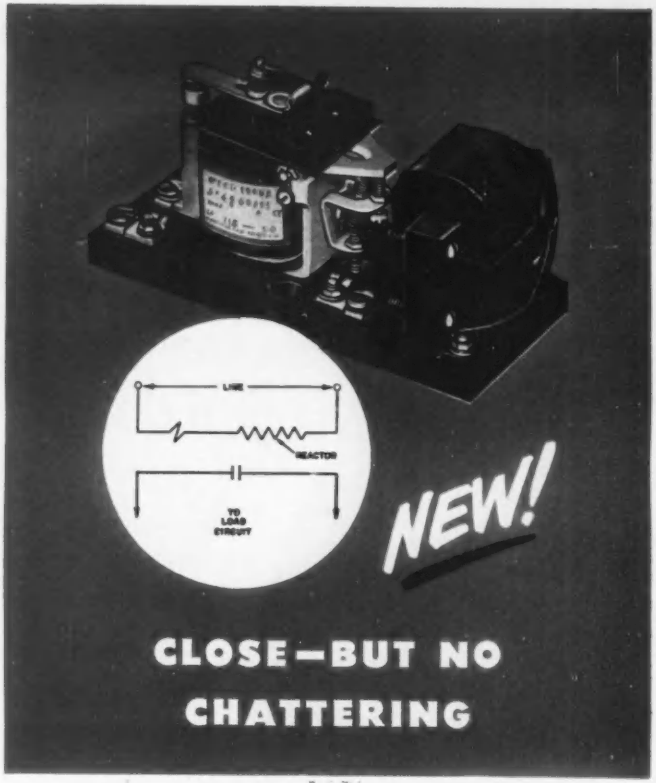

New A-C voltage-sensitive relay makes ideal safety device

Bulletin 401 describes how voltage differential between pick-up and drop-out can be set at 10% (5% on special order)—without chattering—on Ward Leonard's new a-c magnetic relay.

Designed for safeguarding single phase a-c motors (such as on washing machines, oil burners, etc.) against burn-out caused by low voltage, the 401 relay is also ideal for a-c lighting and power bus transfer, voltage regulating, etc.

A small saturable reactor, connected in series with the relay coil, acts as a variable impedance, varying with voltage drop. Since it is the major impedance in the circuit, wide current variations through the coil can be obtained with small line voltage variations.

Being a power-type relay, it provides good contact, good make-and-break. Write for Bulletin 401. WARD LEONARD ELECTRIC CO., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

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New Catalogs .....continued

quick method of determining the AISI type number, technical data and information on the workability of each of the stainless steels made by this firm. Also listed are notes on corrosion and welding and a chemical analyssis table.

(49) LIME HYDRATOR—Hardinge Co., Inc. Bulletin 49, 8 pp. Opens with a discussion of the lime hydrating process, proceeds with a description of the firm's equipment, and shows typical applications. Cutaway views, schematic diagrams and photographs.

(50) SYNCHRONOUS GENERATORS—General Electric Co. Bulletin GEA5470, 4 pp. Explains the construction details with photographs of components and outlines the advantages of this group of synchronous generators which range from 1.875 to 50 kva.

(51) HYDRAULIC SEALS—Goshen Rubber Co., Inc. Catalog C, 25 pp. The first 20 pages are devoted to a discussion of the physical properties of this firm's O-rings for hydraulic applications and the effects on them of various chemicals. Included are installation notes and dimensional data. The last five pages are an assembly of general engineering information concerning general usage, friction value, piston and gland finish and other matters.

(52) WELD SPATTER PROOFING—G. W. Smith & Sons, Inc. Catalog, 4 pp. Shows the advantages of using a coating which when applied to surfaces to be welded permits weld spatter to be wiped or brushed off after the welding is done.

(53) STEAM CAPACITY—Marine and Industrial Products Co. Chart. Graphical display for determining Steam capacity required from safety valves to give full protection in case of pressure reducing valve failure.

(54) FLEXIBLE COUPLING—Link-Belt Co. Folder 2363, 4 pp. Contains dimensions, weights, service factors and horsepower ratings of a group of roller chain flexible shaft couplings as well as detailed data on protective casings for the couplings.

(55) CONVEYOR CHAIN—Link-Belt Co. Folder 2344, 4 pp. Illustrated description of the design features, installation methods and advantages of a flat top type conveyor chain used for carrying bottles, cans and similar products.

(56) DUST COLLECTORS—Aget-Detroit Co. Catalog 605-2, 38 pp. For each of the models, in turn, is given recommended uses, ratings, specifications, inlets available and accessories. Next follows an illustrated display of

a large number of applications for grinding machines, drill presses, lathes, and other machine tools.

(57) PYROMETER ACCESSORIES—Bristol Co. Bulletin P1238, 56 pp. The first section is given over to a theoretical discussion of pyrometry and thermocouples and their application and installation. Charts and diagrams are used freely to illustrate the points made. The second section is a buyer's guide which catalogs and describes the various thermocouples and accessories that the Bristol Co. produces. The last section contains thermocouple calibration data in chart form for a number of metal combinations.

(58) WATER LEVEL GAGES—Bristol Co. Bulletin L700, 24 pp. Contains information on a number of gages for measuring and controlling liquid levels. These are divided into groups according to operating type, i.e., float, pressure, differential pressure, air bubbler and others. Each is described and illustrated and for each is shown diagrammatically typical installation methods.

(59) TELEMETERING—Bristol Co. Bulletin DM029, Folder. Contains a photograph and a brief description of each of a number of installations of the firm's system for regulating of variables such as pressure, water level and others that affect the quality, uniformity or cost of a product.

(60) SCREW CONVEYORS — Fort Worth Steel & Machinery Co. Catalog Section 200-B, 40 pp. Outlines construction details, ratings and other characteristics of a group of helicoid screw conveyors and accessories for moving bulk materials such as grains, food products, sulfur, coal and similar materials. Near the end is given data on vertical screw elevators.

(61) STEAM TRAP PROBLEMS—V. D. Anderson Co. Catalog, 36 pp. Shows how to calculate condensation loads and select traps for such equipment as unit heaters, jacketed kettles, autoclaves, submerged surfaces, kitchen and laundry equipment and others. Specifications and capacities for the manufacturer's traps, air release valves and pipe line strainers are included.

(62) REFRIGERATION—General Motors Corp. Booklet, 93 pp. Replete with illustrations and diagrams in color, this booklet traces the historical development of refrigeration, tells how the modern refrigerator works, describes food freezers, gas refrigerators and air conditioning equipment and concludes with an outline of future developments.

(63) DEMINERALIZER — Penfield Mfg. Co., Inc. Brochure, 6 pp. De-

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That multi-tapped channel resistor is a Ward Leonard suggestion to reduce the cost of maintaining constant voltage for a Diesel train's auxiliary services over the entire speed range.

Originally, the voltage regulator used 16 multi-tapped resistor tubes to give 50 resistance steps. Substituting two multi-tapped Ward Leonard channel resistors simplified mounting so as to save 25% in overall costs.

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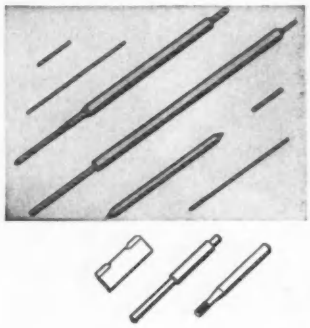

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New Catalogs .....continued

scribes an electrically operated unit for providing high purity water in small amounts as well as equipment for producing pure water in industrial quantities.

(64) TERMINALS AND CONNECTORS—Thomas & Betts Co. Bulletin 61, 40 pp. Illustrated listing of electrical pressure terminals and connectors. Included also are data on installing tools and some tables of general engineering information on wire sizes and similar matters.

(65) CELLULAR RUBBER—Sponge Rubber Products Co. Catalog, 20 pp. A technical discussion illustrated with numerous graphs on the properties of cellular rubber. Among the properties tested are compression, heat and aging effects, flexing, tensions, insulation resistance to oils and chemicals, toxicity, and numerous others.

(66) COLLOIDAL GRAPHITE—Acheson Colloids Corp. Bulletin 427, 6 pp. An illustrated presentation of a number of applications of a parting compound used to prevent sticking, galling and freezing of screws, molds, clutch plates, and similar parts.

(67) VENTURI BALL VALVE—Paul Valve Corp. Cardboard model. Demonstrates the operating features of this firm's product by simulating its action.

(68) WIRE FORMS—E. H. Titchener & Co. Folder, 6 pp. Display some wire forms, welded wire assemblies and stampings as examples of work that the firm can perform.

(69) WELDING ALLOY STEELS—W. J. Holliday & Co. Inc. Bulletin 907, 4 pp. Outlines a procedure for welding three steels, X1515, X1545 and a chromium molybdenum alloy plate. Characteristics of a number of electrode types are listed in chart form.

(70) CLEANING FERROUS METALS—Pennsylvania Salt Mfg. Co. Bulletin, 8 pp. Compares the characteristics of this firm's alkaline cleaner with others and then shows a number of methods for using it, namely, soak tank, spray, electrolytic, barrel, steam gun, and manual.

(71) WEIGHING EQUIPMENT—Richardson Scale Co. Bulletin 0450, 6 pp. Shows a number of types of automatic weighing equipment and lists the types applicable for each kind of material.

(72) SPEED CONTROL—Reeves Pulley Co. Bulletin G-509, 12 pp. An explanation of the operating principles and construction details of three types of infinitely variable speed controllers is followed by charts showing dimensions and capacities of each line. Some space is also devoted to a display of auxilliary units.

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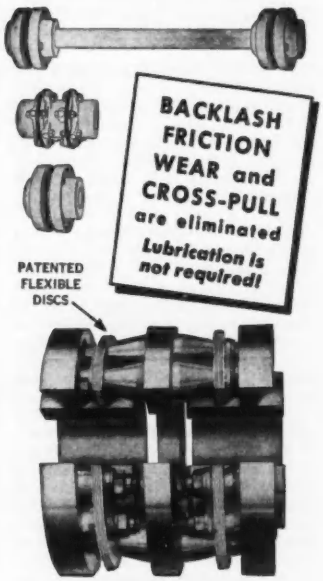

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MEETINGS

April 8-12

AMERICAN CHEMICAL SOCIETY—119th National Meeting, Cleveland and Statler Hotels, Cleveland, Ohio.

April 8-12

ELECTROCHEMICAL SOCIETY—Annual Meeting, Wardman Park Hotel, Washington, D. C.

April 16-18

AMERICAN SOCIETY OF LUBRICATION ENGINEERS—National Convention, Bellevue-Statford Hotel, Philadelphia, Pa.

April 16-18

SOCIETY OF AUTOMOTIVE ENGINEERS—National Aeronautic Meeting and Aircraft Engine Display. Hotel Statler, New York, N. Y.

April 17-20

AMERICAN MANAGEMENT ASSOCIATION—National Packaging Conference and 20th Annual National Packaging Exposition, Atlantic City Auditorium, Atlantic City, N. J.

April 22-26

AMERICAN CERAMIC SOCIETY—53rd Annual Meeting, Palmer House, Chicago, Ill.

April 23-26

AMERICAN FOUNDRYMEN'S SOCIETY—Annual Meeting, Buffalo, N. Y.

April 23-25

NATIONAL ACADEMY OF SCIENCE—Annual Meeting, Academy Building, Washington, D. C.

April 25-26

METAL POWDER ASSOCIATION—Metal Powder Show and Seventh Annual Meeting, Hotel Cleveland, Cleveland, Ohio.

April 30-May 1

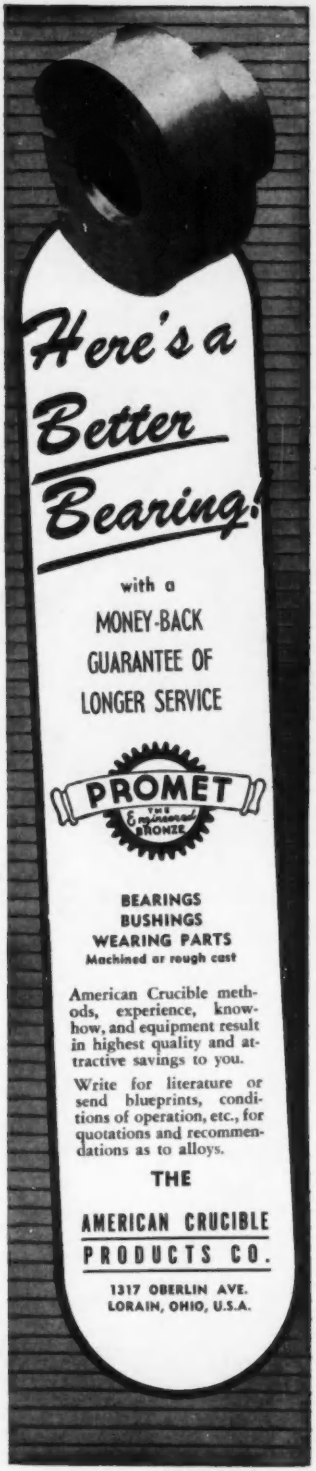
BRITISH INDUSTRIES FAIR—Olympia and Earls Court, London and Castle Bromwich, Birmingham, England.

April 30-May 4

MATERIALS HANDLING CONFERENCE AND NATIONAL MATERIALS HANDLING EXPOSITION sponsored by the American Material Handling Society — International Amphitheatre, Chicago, Ill.

May 9-12

ACOUSTICAL SOCIETY OF AMERICA—Annual Meeting, Wardman Park Hotel, Washington, D. C.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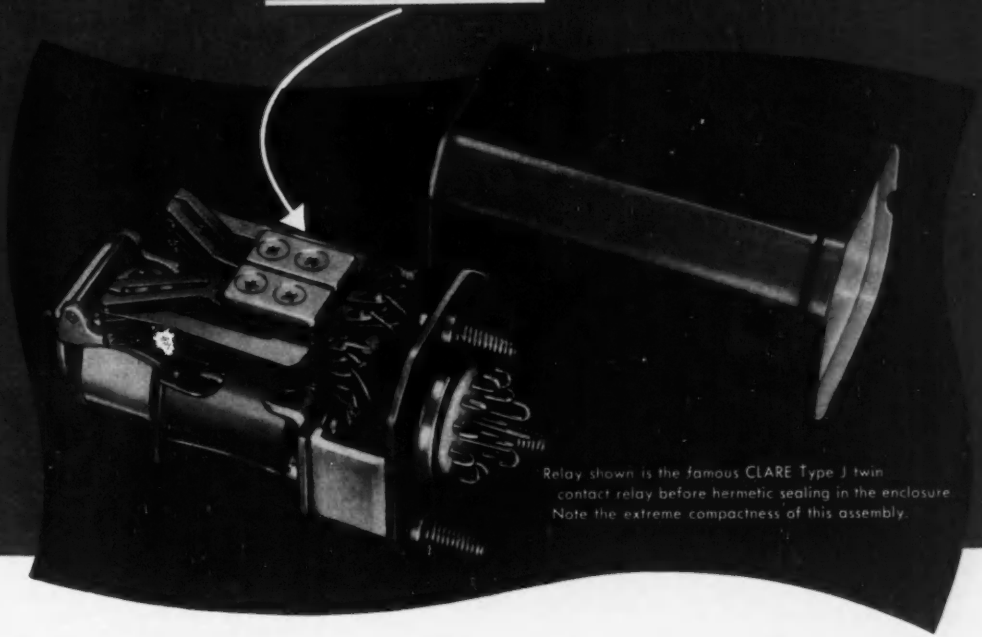

Relay shown is the famous CLARE Type J twin contact relay before hermetic sealing in the enclosure. Note the extreme compactness of this assembly.

HERMETIC sealing, as practiced by C. P. Clare & Co., provides the most perfect seal ever devised to insure ideal relay performance under all conditions.

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Write for 36-Page Clare Bulletin No. 114

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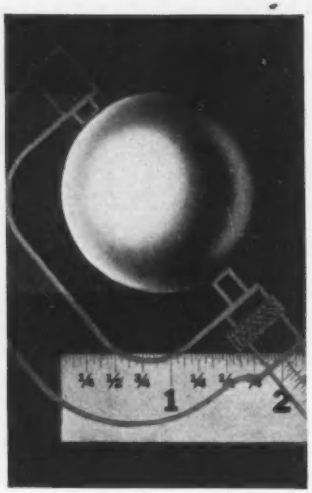

but oh—how important

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Sans, Souci

Ad Libbing by the Editor

Writing technical articles and editorials gets terribly tiresome and boring. It is just too meticulous a job. Everything has to be so accurate and precise. So I decided to start this column or columns wherein I can let down my hair, blow off steam and throw superlative accuracy to the dogs. You know what I mean. Perhaps I ought to call it "The One Man Bull Sessions" instead of Sans, Souci. Particularly so in view of the fact that Sans, Souci means nothing to most readers. So I guess my first job is to explain Sans, Souci.

No! Sans, Souci is not the name of a babe I might have met on my travels. Those readers who took French in their sophomore year or elsewhere might recognize Sans as meaning "without". Now Souci is not a dirty word nor does it relate to clothes or raiment. It is merely French for "Worry".

My former boss, Dutch Wynkoop, will probably say, "Why that blankety old Sour Puss. What does he mean by calling his column 'Without Worry'. Why he is the worrymost editor there ever was. Always crabbing about something!" Maybe Dutch is right, maybe not. I haven't met all the editors he ever worked with. But Dutch is wrong anyhow because I have a comma between Sans and Souci and thereby hangs a tale, and this is it.

The Potsdam Palace

Right plunk in the center of the old Kaiser's palace in Potsdam, up near the roof, the architects have a name for it, are chiseled in stone these words and punctuation, "Sans, Souci." If you get a hold of the right guy, or guide I should say, he will explain the comma. And this is the explanation: When Kaiser Frederick the Great, or perhaps it was some other Kaiser, built this palace he called it Sans, Souci and ordered that the two words be chiseled into the stone with a comma in between. "Why the comma?", he was asked.

"That is easy", says Freddie, "I am going to live in the left side of this palace, and I'm telling you I'll do no worrying in my family life. But the right side of this building will be my executive offices and there I'll do my worrying. So to indicate its Sans Souci on the left side and Souci on the right side, you will put a comma between the words."

Well, everything other than this

on presses— printing frames— vacuum-back cameras— ATF uses GAST rotary air pumps

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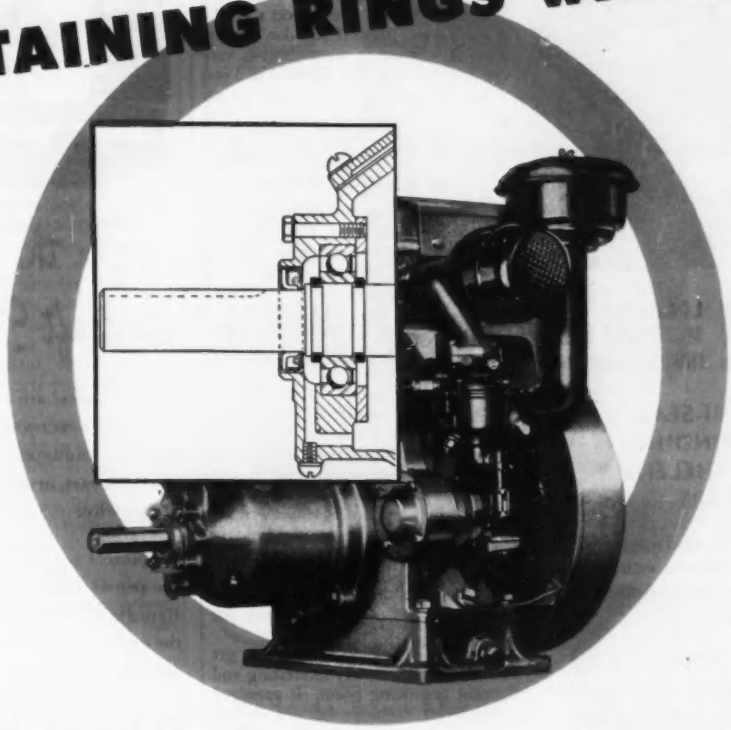

These inexpensive, efficient artificial shoulders save metal and money on Wisconsin air cooled heavy duty engines.

And in addition to saving money and metal, retaining rings save many costly hours in assembly time. Instead of the former wasteful practice of cutting down large shafts, you can redesign to groove smaller shafts and use these high grade steel rings. In your housings, too, rings will save money and improve your products, your machines and your profits.

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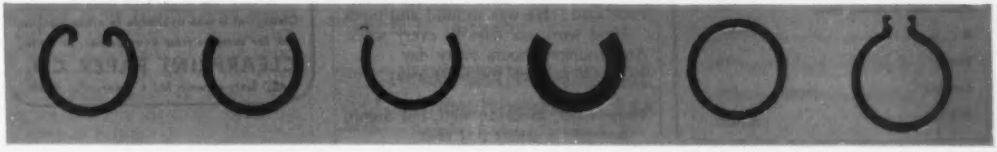

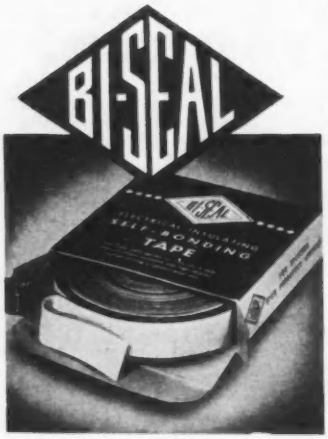

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Address .....

Sans, Souci ..... continued

column in PRODUCT ENGINEERING is my Souci, but this column will be my Sans Souci. If I exaggerate, confuse, aggravate or even misinform the reader in this column, it will not Souci me. Colloquially, the heck with it. I am going to just say what I please and how I please, and I hope you will like it but I won't Souci if you don't. Anyhow, it will all be non-technical, very random, hodge podge perhaps, and just a lot of anecdotes I pick up in my comings and goings. But no dirty stories. So here goes. . . .

My Club Car Friend

In the club car on the train from Chicago to New York I struck up a conversation with a congenial looking tall individual. It wasn't long before I asked my standard question, "What is your line of business?" He turned out to be Mr. E. B. Wilkinson of the law firm of Wilkinson, Witwer & Moran of Chicago.

Now my objective in getting acquainted with people in club cars is to get leads for PRODUCT ENGINEERING articles or to get background information concerning engineering design. Or perhaps to find a reason for putting a few drinks on my expense account. I wouldn't expect to get the kind of information I want from a lawyer, but believe it or not friend Wilkinson gave me a lot of interesting information about industrial activity, but not for publication.

However I did manage to get from him an extremely interesting and thought provoking poem. It appeared in a special executive bulletin of the National Association of Chain Drug Stores. If for no other reason than to justify the entertainment item on my expense account, I am herewith publishing that poem in full.

Who's Going to Maintain the 'Pore House'

My father, poor, misguided gent,
Wasted his life; a life misspent
In working hard, and working late,
From six A.M. 'Till way past eight.

Poor Dad! He'd fuss and fret and toil,
And burn the sooty midnight oil,
For nothing but a little cash
To buy the daily beans and hash.

Poor Dad! He was so mild and meek
He'd work six days in every week,
And fourteen hours every day
To try to keep the wolf away.

Thus father, meaning well, but dumb,
Amassed a rather tidy sum

ARTIST • BRUCE BUTTE

In the Aircraft Industry

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Sans, Souci .....continued

With which he planned to buy some beers
To brighten his declining years.

The NEW DEAL came, and simple Dad,
Who worked so hard for all he had,
Awoke one morn to find that he
Was now a public enemy;
A Scrooge; a louse, a Social cyst:
An economic Royalist!

So Dad, industrious but dumb,
Is now the source from which will come
The coin to buy the gasoline
For some poor underdog's machine,
And bring the more abundant life
To every loafer and his wife.

From Dad will be extracted sums
For radios to cheer the bums,
And furnish booze for ne'er-do-wells
Who help to raise imported hells,
Poor Dad, the faithful, Trustful Goon
Was born just thirty years too soon.

Now any guy is just a cheat
Who says men ought to work to eat.
He's simply nuts! Out of his head!
Sit on your tail, or stay in bed;
The Government will see, by gad!
That you get yours, from chumps like Dad.

All of which reminds me that I have to send Uncle Sam my income tax report and check, and what a pile of souci that is.

A Visit With Pigott

Couple of weeks ago I went down to Pittsburgh to have a visit with R. J. S. Pigott, director of engineering of Gulf Research & Development Company. Now this is not a real estate or exploration company operating in the Gulf of Mexico. It is the research branch or section or whatever you call it of Gulf Oil Company. Many of you know Reg Pigott as the former president of the S.A.E. or the organizer and first chairman of the A.S.M.E. Special Research Committee on Fluid Meters, etc. etc. You'll know more about him when you read his "curtain raising" article "The State of Art in Design" in May PRODUCT ENGINEERING.

Anyhow, "Reg" as his friends call him, is mighty interesting to listen to. He was telling me how we are all too likely to be satisfied with things as they are and when we do start trying to find a new way of doing something, a better way, we all too often deal the same hands all around and then wonder why the score comes out the same as before.

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OUR READERS SAY

Old Problem Still Baffles Engineers

To the Editor:

We build right helicoids with diameters to 8 ft, pitches to 4 ft, flight widths to 12 in. and plate thicknesses to ¼ in. for use in conveyors, classifiers and other machines. Since I am required from time to time to design these helicoids, I have searched, without success, for a published formula for determining the exact dimensions of a plate development which would readily form into the exact helicoid upon being heated and pressed in a formed die.

Descriptive geometry provided me with my first satisfactory solutions, and I have since derived an equation which, using the assumptions followed in a geometric layout, gives me more consistant results.

I am interested in securing a workable and exact equation, if such a thing is extant, and would be glad to exchange information with anyone interested. I have secured much useful information through your "Our Readers Say" columns, and I submit the above to you with that disposal in mind.

—WILLIS G. GROTH
Hirsch Brothers Machinery Co

Ed—The problem you pose is an old one that has bothered sheet metal fabricators for a long time, and no one, so far as can be ascertained, has come up with what may be called a "workable and exact equation".

Descriptive geometry can provide equations that are theoretically true on the assumption that the materials worked are uniformly stretchable or formable. Unfortunately, no such material is available to the fabricator. Permissible tolerances and spring back peculiar to the method of forming are other factors that are not readily introduced in any derived theoretical equation.

Perhaps, however, one of our readers may have something to contribute.

Editor Eats Humble Pie

To the Editor:

Again I wish to refer to the article on page 155 of your November 1950 issue entitled "Solving the Pythagorean

Principle of the Slide Rule." I wish also to refer to the correspondence concerning this article on page 210 and 218 of your January 1951 issue.

Several of my associates and I have attempted to follow the "ultra-simple" method on page 210 but it appears that the correspondent must have a special slide rule. Those of us with standard rules do not find the numerical values of the angles as described in this letter.

On page 218, you print a version of my letter to you of November 17, 1950. I presume it is to be expected that the editors would change an engineer's language. It is unfortunate, however, that the same editors were so indifferent to the technical content of the letter as to publish it with such typographical errors as to make it ridiculously incorrect. The second paragraph of that letter refers to setting the quantity g over the quantity h, thus obtaining the ratio of those quantities. We then refer to the square of that ratio, namely, $\left(\frac{}{h}\right)$ writing it in the form $\left(\frac{g}{h}\right)^2$.

The printed version of the letter is incorrect in replacing the h in the denominator with the letter n and in showing only the numerator squared instead of the ratio squared. It appears to me that if this had been edited with a view to the content, it would have been transcribed correctly.

—D. E. BRAINARD
Schenectady, N. Y.

Ed—Since you are perfectly correct in your comments on the poor work we did of transcribing your letter, we can do nothing but apologize for a bad job of proof reading.

As for your remarks on the method of solving the Pythagorian Principle on the slide rule described by Celeste M. Fightmaster in a letter on page 210 of the January issue, we, too, were unable to reach the answers contained therein. However, as Mr. D'Entremont points out in a letter in these columns, this method requires a Log-Log Deci-Trig type of slide rule.

Editor, Watch Those Powers

To the Editor:

On page 167 of the November 1950 issue of PRODUCT ENGINEERING, you published a Nomographic Chart entitled "Properties of Rectangular Section." Your attention is called to the following errors:

(1) Equation $I_0 = I_a + Ad$ should read $I_0 = I_a + Ad^2$. (2) Equation $I_a = \frac{wh^2}{12}$

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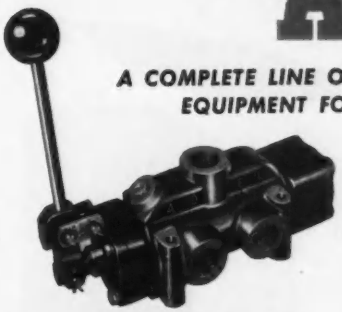

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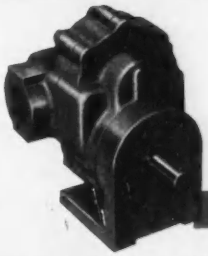

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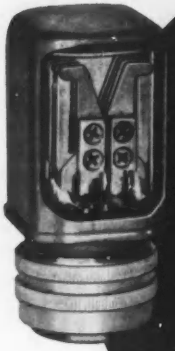

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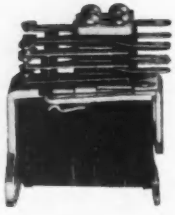

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should read $I_n = \frac{wh^3}{12}$. (3) Equation $Z = \frac{I_n}{c} = \frac{wh^2}{12}$ should read $Z = \frac{I_n}{c} = \frac{wh^2}{6}$ or $Z_n = \frac{wh^2}{6}$ for the section modulus about the neutral axis. (4) The explanation given in the paragraph "Whenever the dimensions of the rectangle are beyond the limits of scale. . . . . ." is applicable for the "h" value only. For values of "w" beyond the limits of the scale, section properties are directly proportional to "w", and therefore should be corrected correspondingly. (5) In the example $I_n = 26.0$ should read $I_n = 26.0$ in^4. (6) At the bottom of the I_n scale the 0.8 value should read 0.08.—ROBERT T. SMITH *and* HOWARD R. BREUER
Franklin Institute

Ed—Apologies are certainly in order for the typographical errors found by Mr. Smith and Mr. Breuer. However, it should be pointed out that the chart is correct in spite of these errors.

What Slide Rule Do You Use

To the Editor:

Published in the January 1951 issue of PRODUCT ENGINEERING are letters from D. E. Brainard and Celeste M. Fightmaster pertaining to the article in the November issue, entitled "Solving the Pythagorean Principle on the Slide-Rule."

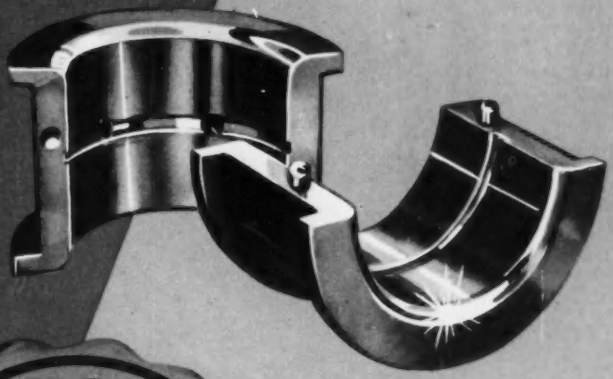
D. E. Brainard gives a method using the ratio $\frac{h}{g}$ instead of $\frac{g}{h}$; whereas the method in the published article used the index of the "B" scale, his method uses the index of the "A" scale. In neither case is there need for using the runner, and one is as good, in fact, the same as the other.

Celeste M. Fightmaster gives a standard method which applies only to slide-rules of the Log-Log Deci-Trig type in which the sine and tangent scales are on the slider. For those who, like myself, use this slide-rule, the method is far superior to any other, but the users of this rule are a minority.

The published article was intended to apply to all types of rules, including the ordinary Manneheim rule. This rule has but five scales, A, B, C, D, and CI on its face, the sine and tangent scales being on the reverse side of the slider.

Users of the Mannheim rule may also wish to know the angle when they solve for the values of the legs. The procedure is as follows: after the first step of setting h over g, make a note of the value appearing on the "C"

(*Continued on Page* 238)



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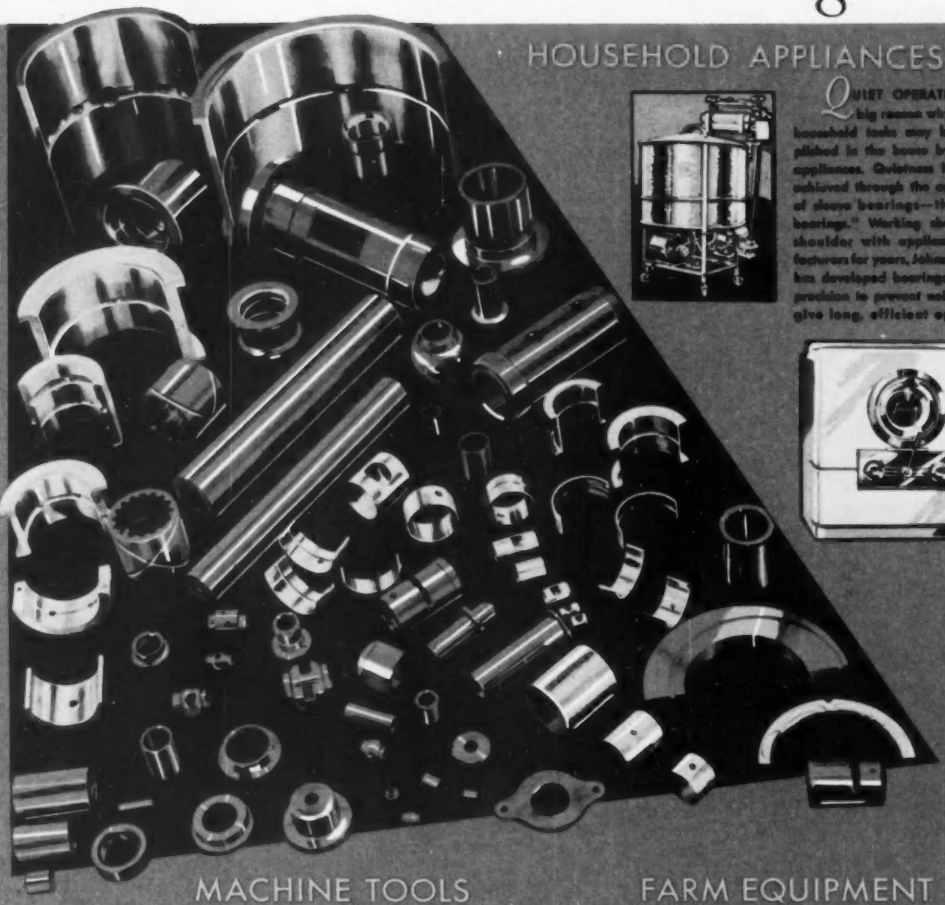
SLEEVE BEARING HEADQUARTERS

50 Years OF PROGRESS IN SLEEVE BEARINGS

Johnson Bronze

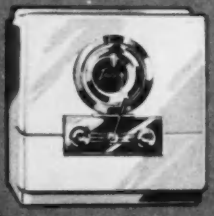
NEW CASTLE, PENNSYLVANIA

A lot has happened in Sleeve Bearings in . .



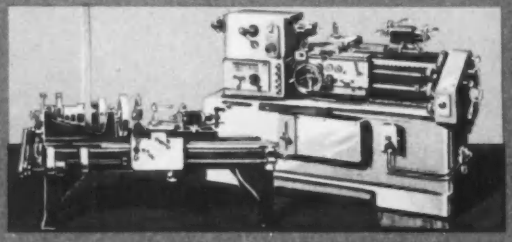
HOUSEHOLD APPLIANCES

QUIET OPERATION is a big reason why so many household tasks may be accomplished in the home by modern appliances. Quietness has been achieved through the application of sleeve bearings—the "quiet bearings." Working shoulder to shoulder with appliance manufacturers for years, Johnson Bronze has developed bearings of great precision to prevent noise and to give long, efficient operation.



MACHINE TOOLS

FIFTY YEARS OF PROGRESS in Johnson Sleeve Bearings has enabled machine tool builders to attain today's accomplishments. Finer and more accurate Johnson Bearings have permitted constantly increasing load, higher speed and rate of feed, while maintaining highest degrees of accuracy, no chatter from wear, and continuous operation over long periods of time. Johnson Sleeve Bearings are engineered for these requirements and are widely used throughout the entire motive and operating units.



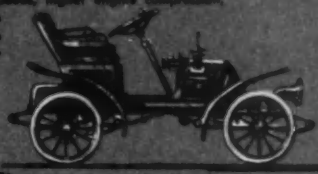
FARM EQUIPMENT

MODERN FARM EQUIPMENT does farm work faster and better year after year, and allows the farmer more leisure than ever. Johnson Bronze has studied for years the requirements of this equipment—strength, stamina, higher speed, greater horsepower, grit and corrosion resistance. Through research and devotion to these problems, Johnson Sleeve Bearings have become the standard in the vast majority of tractors and farm machines. Johnson's latest contribution is the Aluminum Alloy Bearing, the most modern type of sleeve bearing developed for this service.

50 Years

AUTOMOBILES

TODAY'S SLEEK, high-powered automobile shows tremendous progress over the early "gas-buggy." Before many of the developments in automobile operation could be achieved, sleeve bearings had to be designed and produced to permit higher speeds, higher engine compression, and greater endurance. From the early days Johnson Bronze has worked closely with the automotive industry and has been a major source of supply for sleeve bearings.



ALTHOUGH using unlike metals for bearings and shafts still remains the fundamental principle in Johnson Sleeve Bearings, great changes have occurred in them since 1901. New conceptions of bearing materials have marked important steps of progress. Metals have been combined for greater serviceability and for lower cost to the user. Research and engineering have been responsible for many changes in design and application.

A glance back at the early 1900's will reveal how much the mechanical world has advanced. Today's operating speeds of automotive equipment and other machinery were inconceivable then. Many other bearing requirements have changed, too . . . operating temperatures, loads, shock resistance, continuous operation. Johnson Bronze has accepted each challenge of mechanical progress as it appeared, and each time has developed a sleeve bearing to answer the need. Most of the Johnson Bearings of today show only superficial resemblance to those of fifty years ago.

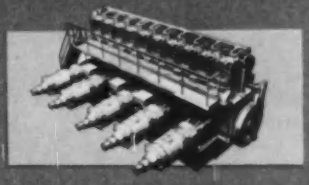
The first sleeve bearings produced by Johnson Bronze were cast bronze bearings and bronze castings heavily lined with babbitt. Before long, new types were necessary because of the rapid development of the automobile and the need for higher speeds in industry. Johnson Bronze brought out the graphited bearing in 1920, and bronze bearings with thinner babbitt linings in response to the demands of progress. Next came the Johnson Bronze Thin Wall Bearing in 1924—known as rolled sheet bronze. Babbitt on steel was introduced in 1932 in line with new engineering ideas in the automotive and electric motor industries. The year 1939 saw the introduction of Ledaloyl, the Johnson Bronze Bearings produced by powder metallurgy. These oil-impregnated bearings filled a growing need for light-duty applications where lubrication is difficult or impossible to achieve. Still more recently, in 1942, Bronze-on-Steel became an important addition to the farm implement field, and more recently in other fields. Johnson Aluminum Alloy Bearings are the latest development and are continually finding new applications.

As important as the development of new styles in sleeve bearings, perhaps, are other steps of progress. The improvement and refinement of bronze alloys and their standardization have been triumphs in the bearing industry. Johnson Bronze manufacturing methods have kept pace with the growing demand for greater precision, closer tolerances, and more perfect fit.

On this fiftieth anniversary Johnson Bronze is duly proud of its contributions to the progress in sleeve bearing manufacture.

DIESEL ENGINES

THE MODERN diesel engine has progressed greatly from the original diesel invention. Today it is used for all kinds of stationary and motive power—railroads, trucks, road and farm equipment, marine vessels, airplanes, stationary engines, and unexpected other uses. Johnson Bronze research and engineering have played an important part in becoming the major supplier of sleeve bearings for the diesel industry since its inception.



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During the years of leadership by the late P. J. Flaherty, the organization grew and expanded widely. A new conception of service was installed . . . a nation-wide warehouse system, plus a network of jobber-distributor connections, provides stocks of Johnson Sleeve Bearings in every city and county in America. Industrial buyers and users of bearings throughout the country today can get expert advice from trained representatives and prompt shipments of their bearing requirements. Our modern Export Department maintains excellent connections in every country where American products can be sold. Now, in 1951, Johnson Sleeve Bearings are known and used around the world.

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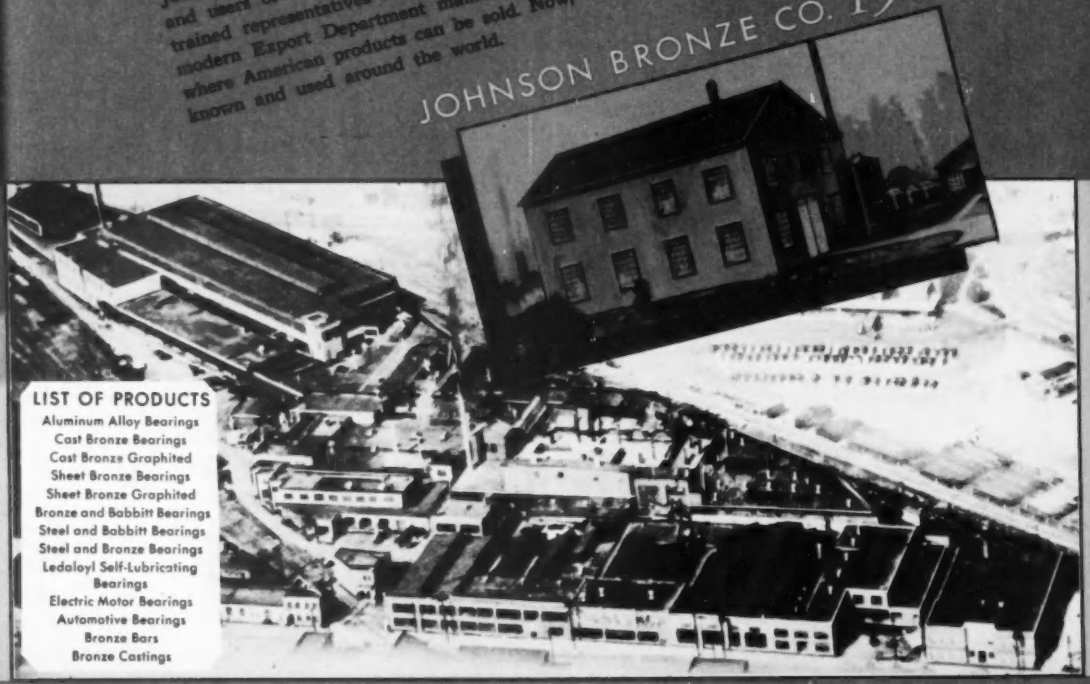

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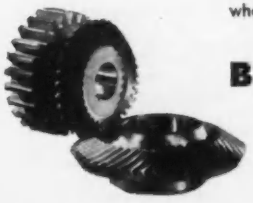

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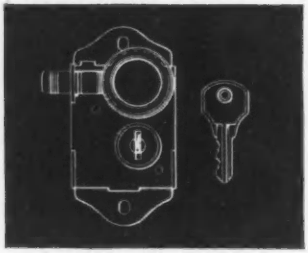
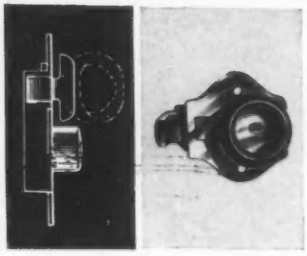


FOR PANEL BOARDS a flush-with-the-surface lock and latch combined. The lock has a sturdy 5-disc tumbler mechanism. When unlocked, the ring pull operates the bolt (see below), allowing the lock to be used as a latch. The lip bolt does not require the use of a strike on steel doors.



(left) Profile illustration of lock above shows how ring pull is pulled out to operate bolt. At right is a Flush Panel Board Catch, for use where no lock is required.

• See Corbin Illustrated Catalog No. 99B for full details on Corbin Locks and Catches. If you do not have a copy, we shall be glad to send one to you.

Be sure . . . with CORBIN

CORBIN CABINET LOCK DIVISION
THE AMERICAN HARDWARE CORPORATION
NEW BRITAIN, CONNECTICUT

scale over the index of the "D" scale. This is the tangent of the angle. After finding the value of the leg sought reverse the slide (or whatever is necessary on your particular rule) and find the angle from its tangent.

If you prefer to use Mr. Brainard's method, then read the value of the tangent on the "D" scale under the index of the "C" scale, after the first setting of g over h.

If the hypotenuse should be one of the known legs, then either the sine must be read (instead of the tangent) or the sine of the complimentary angle, which is the cosine of the angle you wish to find.

An error is noted in the transcription of Mr. Brainard's letter, in that n has been used in place of h and the ratio $\frac{(g)}{h}$ should be squared instead of the dividend g only. My thanks to these readers for their interest and their comments.

—HENRY W. D'ENTREMONT
Montclair, New Jersey

Reduced to Simple Language

To the Editor:

Some time ago I had occasion to investigate the subject of edgewise loaded plates and couldn't find a thing in simple language for the busy man. Therefore, I dusted off my Timoshenko's "Elasticity", Presscott's "Applied Elasticity", Roark's "Stresses and Strains" and Orton's contributions, digested the same and reduced them all to something I believe to be simple. Maybe you will think so too.

When a plate, rolled or cast, is loaded on its edge, there may be wrinkling or buckling under the load, depending upon the resulting stresses. This stress condition is solved by the simple procedure outlined below with an accuracy quite sufficient for practical design. The tension and/or compression stresses are usually the maxima to be provided for; occasionally the shear values require investigation.

When the load is almost completely concentrated at a point or a line, extremely high stress concentrations result and there is some local grooving. A much more favorable design is obtained when the load can be spread over some distance L in order to secure approximately a uniformly distributed load. Plate curvature normal to the loading is neglected to simplify matters.

Referring to Fig. 1, the unit compression, S_c, at the point O is,

$$S_c = 0.318\ p(a + \sin a) \qquad \ldots(1)$$

Luster-on ®KHAKI DRAB ZINC DIP BETTER THAN BEST HOPES

Announced a few weeks ago as an olive drab finish for zinc plate by the makers of Luster-on Bright Dips, Chemical Corporation's latest conversion coating is exceeding highest expectations. The first batches in the field indicate even better color and film stability.

Referred to as olive drab or light khaki, Company has settled on official name of "Luster-on KHAKI DRAB". When diluted one part of KHAKI DRAB to seven parts water, the work comes out a light iridescent tan; diluted one to ten, color is rich bronze brown.

Ideal For Defense Work

KHAKI DRAB is an economical, quick, room-temperature dip for work as it comes from zinc plating line. KHAKI DRAB finish will withstand salt spray corrosion tests of 200 hours. This far exceeds government requirements of 100-hour exposure, so KHAKI DRAB should meet any U. S. Government specification. KHAKI DRAB is an entirely new type of formulation, differs from any drab finish on the market.

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When finished part is to be painted or enamelled, Luster-on KHAKI DRAB gives under-paint corrosion protection, prevents attack at paint breaks or scratches, guards hidden surfaces. KHAKI DRAB is the ideal adhesive base to bond paint to zinc, grips to all types of organic finishes, resists chipping or marring.

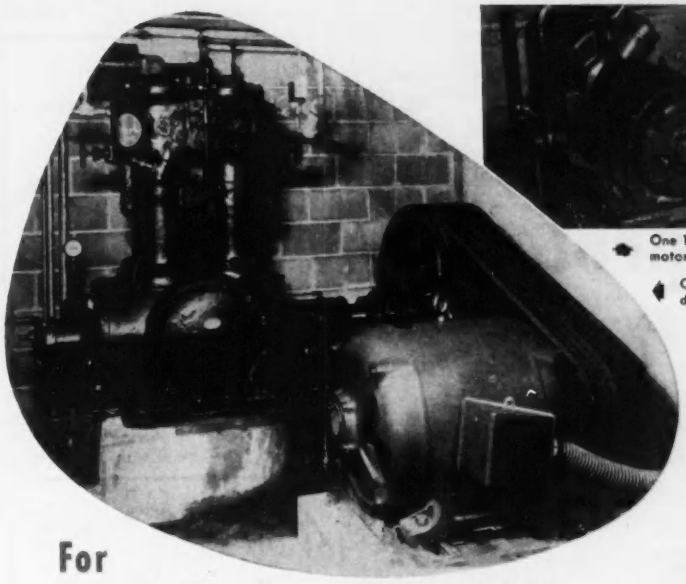
Now Released to General Industry

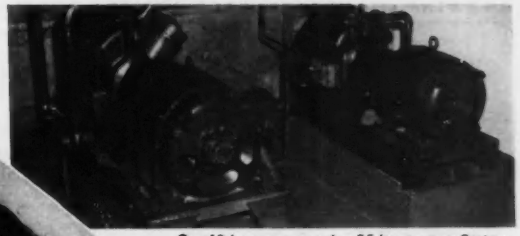
When first announced the new khaki finish was restricted to Government orders. Now Chemical Corporation officials have given nod to full release to include civilian goods (DO's are given preference). Reason given is that new KHAKI DRAB is economical in use of critical materials. Replacing cadmium and nickel with zinc is first economy. This part is now largely required by NPA orders. Second economy is that KHAKI DRAB uses less ingredients in short supply per square foot of work tested than companion Luster-on Bright Dips, Utility-15 and Utility-25.

Sample Parts Treated Free

Sample parts sent to laboratory will be processed with either Luster-on KHAKI DRAB *or* Utility Bright Dip and returned without obligation. Technical advice for conversions to Luster-on is available. Address inquiries to The Chemical Corporation, 59 Waltham Avenue, Springfield 9, Mass.

(Advertisement)





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Century Type SCH, Squirrel Cage polyphase alternating current High Torque motors are ideal for refrigeration compressor applications. They bring compressors up to speed smoothly and easily under full load.

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In addition, Century builds a complete line of electric motors in a wide range of types, in sizes from 1/6 to 400 horsepower. Specify Century motors for all your electric power requirements.

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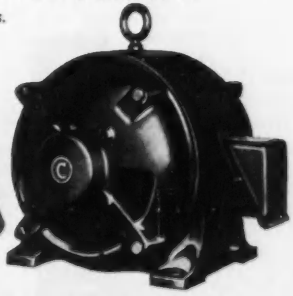

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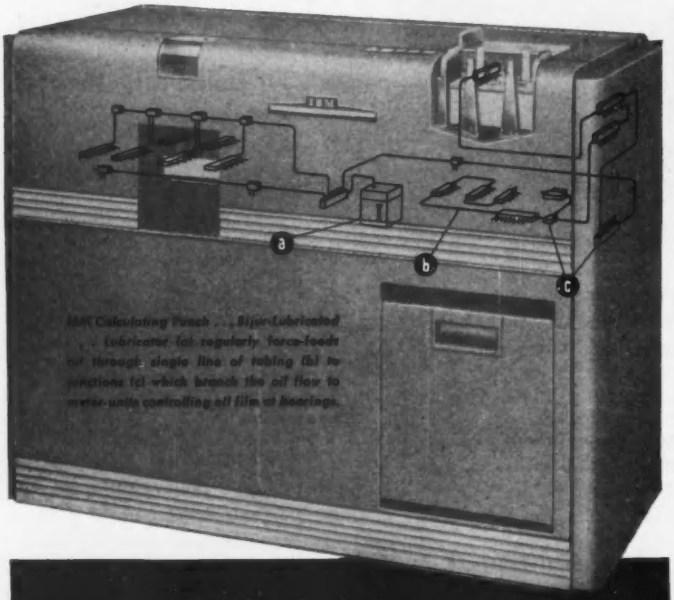

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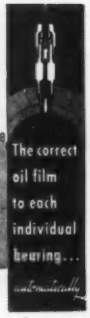

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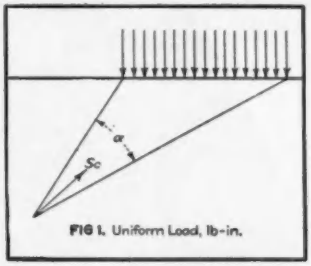


FIG 1. Uniform Load, lb-in.

where 0.318 is the reciprocal of π, p is the pressure on the plate edge in lbs/sq in., a is the angle in radians. The unit shear is

$$S_s = 0.318\ p \sin a \qquad \ldots(2)$$

In Fig. 2, are plotted constant stress circles found by solving Eq. 1. Fig. 2 shows the rate at which the stress is

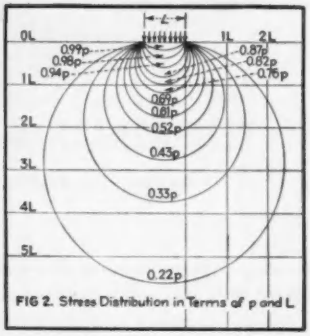


FIG 2. Stress Distribution in Terms of p and L

transferred vertically and horizontally. The horizontal lines 1L, 2L, etc. are in terms of the load bearing width L.

If a vertical section be taken on the vertical center-line of the load, the curve of Fig. 3 results. This curve

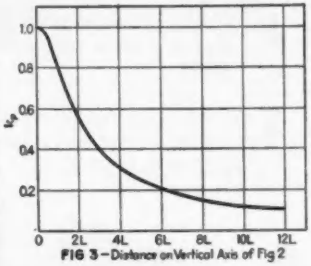


FIG 3—Distance on Vertical Axis of Fig 2

gives stress values in terms of L, the stress value directly under the load being considered unity. From 0.5L to 10L the relationship of proportional stress to L is expressed with sufficient accuracy by

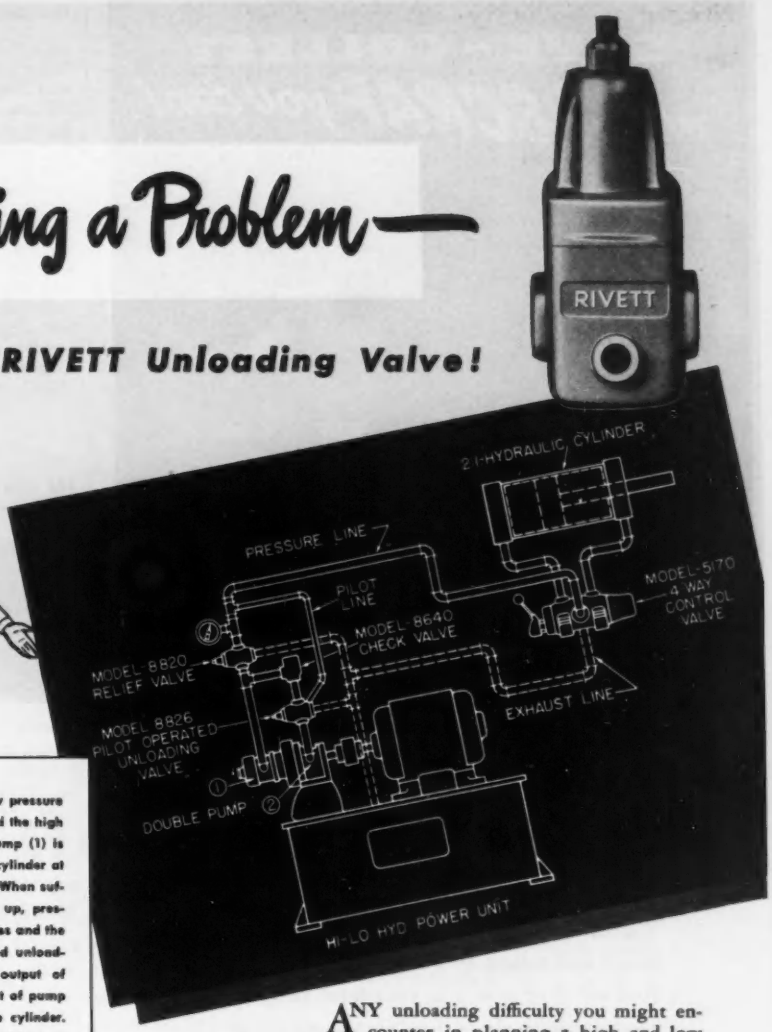
$$k_p = 20.22/(L + 4)^2 \qquad \ldots(3)$$

The numerical value of the stress S_c at any distance along the centerline of Fig. 2 is thus k_p p lbs/sq in.

Whether this stress will wrinkle or

Dumping a Problem—

with this RIVETT Unloading Valve!



The output of both the low pressure high volume pump (2) and the high pressure small volume pump (1) is directed to the hydraulic cylinder at a low operating pressure. When sufficient work load builds up, pressure in the system increases and the Model 8826 pilot operated unloading valve unloads the output of pump (2) while the output of pump (1) is still directed to the cylinder. Direction of piston travel is controlled by Model 5170 hand operated 4-way control valve.

ANY unloading difficulty you might encounter in planning a high and low pressure circuit can be solved by use of the Rivett Model 8826 Unloading Valve. It is employed in oil hydraulic circuits to unload one part of the circuit at no back pressure to the tank, and is operated by pilot pressure from some other part of the circuit. Free flow to tank continues as long as the pilot pressure is higher than the setting of the valve. Available in sizes ¼" to 1½", in two pressure ranges, adjustable from minimum to maximum in each range. RIVETT LATHE & GRINDER, INC., Dept. PE-4 Brighton 35, Boston, Massachusetts.

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buckle the plate depends on the material considered. For example, in steel I-beams, a compression stress at the root of the web fillet of 24,000 lbs/sq in. for static loading is considered quite safe; doubtful cases should be tested by the Euler type column formulae. If the load is symmetrically attached to the plate so that side-wise bending does not appear, the same analysis should hold good for a tension condition. In the same way, if a load be attached well within the boundaries of a plate in such a way that both tension and compression zones are developed, each zone may be considered as taking half of the superimposed p value.

—JOHN SHROEDER CARPENTER
Dunbar, West Virginia

He Got There First

To the Editor:

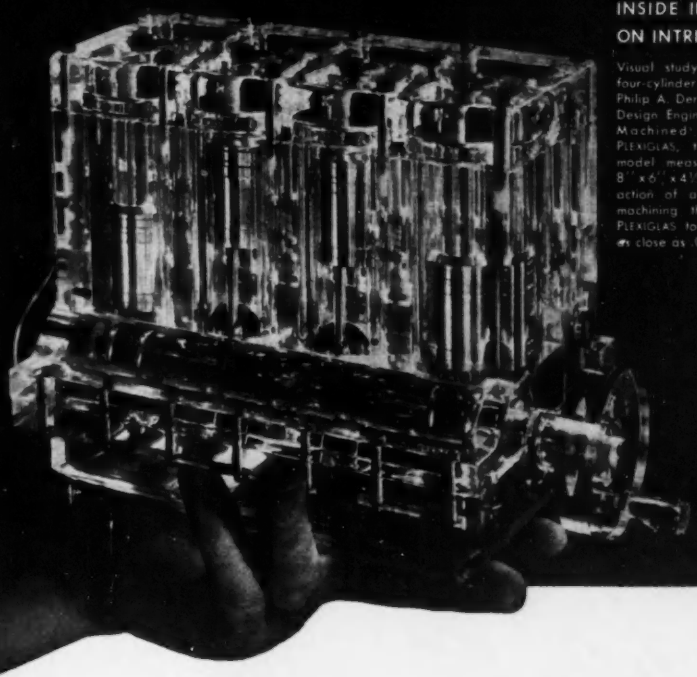
Mr. Kuhlmann's fine beam nomogram with single secant on page 167 in the November 1950 issue of PRODUCT ENGINEERING has been anticipated by the writer's similar single line nomogram in the January 1937 issue of Machine Design. An added feature of the latter nomogram is the radius of gyration, but the area and moment of inertia about edge which appear in Mr. Kuhlmann's are omitted. Also Mr. Kuhlmann's is laid out on a larger scale and is, therefore more accurate.—CARL P. NACHOD
Nachod & U. S. Signal Co.

Left Hand Should Watch Right Hand

To the Editor:

Two rather important errors appeared in the chart, "Inorganic Finishes For Metal Products", appearing in the February 1951 number of PRODUCT ENGINEERING and facing page 148.

The first error is a statement that vitreous enamels are used "usually on gray iron". It is true that sinks, bath tubs and lavatories are invariably finished in vitreous enamels, but the fact is that this represents only a minor portion of the field of uses of porcelain enamel finishes. Using special sheet steel (enameling iron) to give the highest quality of finish, electric refrigerators, home freezer units, all electric ranges and gas ranges, and many other products are finished with vitreous enamel or porcelain enamel as it is commonly called. In addition to its uses for appearance purposes, the abrasion resistance of porcelain enamel has led to its application for



INSIDE INFORMATION ON INTRICATE DESIGNS

Visual study model of typical four-cylinder gasoline engine, by Philip A. Derham and Associates, Design Engineers, Rosemont, Pa. Machined from solid, clear PLEXIGLAS, the hand-operated model measures approximately 8" x 6" x 4½", and illustrates the action of all moving parts. In machining the intricate model, PLEXIGLAS tolerances were held as close as .001".

This PLEXIGLAS Engine Tells Its Own Inside Story

You can look right into this miniature gasoline engine—see every part and check every detail of operation. Machined from solid transparent PLEXIGLAS acrylic plastic, the hand-operated model shows clearly the action of pistons, valves, cams, connecting rod and crank shaft—from any angle.

Clarity, workability, light weight and durability make PLEXIGLAS especially useful in visual study models, demonstration models, and in general product design and engineering work. It machines easily to close tolerances—forms to almost any curvature when heated—is extremely strong even in very thin sections—and is readily cemented to form strong bonds.

These properties—plus gleaming beauty, a complete range of transparent and translucent colors, and resistance to weather and breakage—give PLEXIGLAS ever-growing importance in *full-scale* manufacturing and merchandising. We'll be glad to send you information on PLEXIGLAS sheets —flat, corrugated, and patterned—and on PLEXIGLAS molding powders.

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the protection of equipment such as material handling chutes, textile spindles, and many other applications, none of which are castings.

The second mistake is with reference to the remark that hot-dip aluminum coatings are applied mainly on cast iron. Aluminized sheet steel has been used for automobile mufflers, tail pipes, oven liners, home appliances, furnaces, combustion chambers, heat exchanger tubes and a wide variety of other uses. In fact some of the uses listed in your chart such as oven liners and heat reflectors involve aluminized steel sheet rather than hot-dipped castings. —A. M. LENNIE
Armco Steel Corporation

Ed—Mr. Lennie is correct on all counts. Both of these errors are particularly ironical in view of the fact that in the coming June number of PRODUCT ENGINEERING we are running a comprehensive article on porcelain enamel finishes on sheet steel surfaces, and PRODUCT ENGINEERING has given considerable editorial attention to aluminized sheet steel. Our failure to properly indicate the field of uses for these two finishes was "one of those things" which so aggravatingly occur when tackling a job of the size and scope of Inorganic Finishes of Metal Products. Our thanks to Mr. Lennie for calling this to our attention.

Where Can I Get It?

Magnetic Ferrites

To the Editor:

I am interested in the item on Magnetic Ferrites" on page 92 of your October 1950 issue. Will you please advise me where I can obtain more complete details regarding its source and characteristics?

—ANDREW T. COURT
Detroit, Mich.

Ed—If you will write to the General Ceramics and Steatite Corp., Keasbey, New Jersey, it is believed that you will get the material you seek.

More For Your Money

To the Editor:

Mr. Pat Lennox, your sales agent in this area, recently solicited a three-year subscription to PRODUCT ENGINEERING from me. He was asked at the time if yearly indices of the

periodical are available, as well as what reprints of articles are available.

Because an answer to neither question was immediately accessible to him, he suggested that I make the request of you. —HARVEY S. FREEMAN
Empire Engineering Co.

Ed—Enclosed are copies of our 1949 and 1950 index. Also enclosed is a list of reprints that are available. There are a few other reprints not on this list. These must be requested specifically.

Fluid Drive

To the Editor:

I am much interested in the subject of fluid drives and industrial clutches and I am trying to locate literature regarding the matter. Perhaps you can help me out.
—MAJ. WILLIAM H. MARTHINSEN
Rutgers University

Ed—Enclosed are two copies of a special report run in the March 1950 issue of PRODUCT ENGINEERING. As well, there are included some tear sheets of an article in the October issue entitled "Selecting the Right Fluid Coupling for a Prime Mover." It is hoped these will meet your needs.

Hush-Hush

To the Editor:

We are interested in obtaining information and publications on two different methods of metal drawing, using rubber, or rubber pads, as a part of the necessary drawing equipment.

One of these methods is known as "Guerin" and the other is known as the "Marform" rubber pad method.

If you have any information on these two methods, or if you have any publications containing information on them we will appreciate your advising us the title and also the cost of them. —W. C. LAMBERT
Henrite Products Corp.

Ed—Enclosed is a copy of an article run in the April 1950 issue of PRODUCT ENGINEERING on the Marform rubber pad method of metal forming.

Actually, the concerns behind this development, Glenn L. Martin in Baltimore, Maryland and Hydropress here in New York, have not done too much talking. However, if you want detailed data, the Marform process is, it is believed, a licensee arrangement. It is suggested that you write

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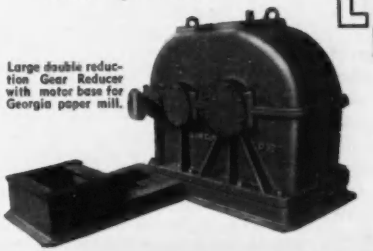

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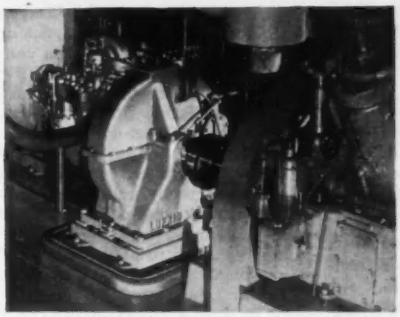

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either to Hydropress, Inc., 572 Lexington Ave., New York 22, N. Y. or to the Glenn L. Martin Co., Baltimore, Maryland.

Insofar as the Guerin process is concerned, we are not too well acquainted with that, and thus we are passing your letter along to the editors of *American Machinist* who perhaps will be able to give you some specific information.

Surface Finishes

To the Editor:

In the September 1950 issue of PRODUCT ENGINEERING there appeared an article on several different methods of measuring surface finishes. We have received a request from our Methods Engineering Department for available information on materials and equipment in connection with this subject from the following companies: Fax Film Co. and Marco Chemicals, Inc.

Also mentioned in this article were two optical comparators, the Merz Pico and the Comtor. We would like to have any information which might be available on these comparators.

—E. F. MCCUSKER
International Business Machines Corp.

Ed—The addresses of the companies you mention are as follows: Fax Film Co., 1200 W. Sixth St., Cleveland, Ohio; Marco Chemicals, Inc., Sewaren, N. J.; (Merz Pico) Photron Instrument Co., 6516 Detroit, Cleveland, Ohio; and Comtor Co., Rumford Ave., Waltham, Mass.

We believe that these companies will be able to help you obtain the information you seek. But, if you run into any difficulty we suggest that you write to the author of the article, Mr. R. P. Trowbridge, General Motors, Engineering Standards, General Motors Building, 3044 W. Grand Blvd., Detroit 2, Michigan.

Uses For Lithium

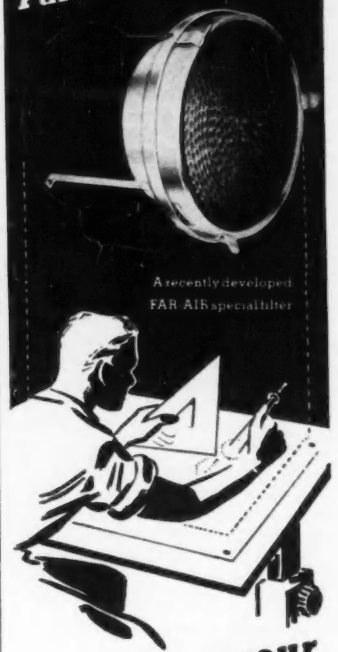
To the Editor:

In your December issue of PRODUCT ENGINEERING on page 116 there is an article concerning the use of lithium as a deoxidizer for nonferrous castings. Will you kindly advise where we may obtain further information on this subject.

—HOWARD A. MAYBERRY
Richmond Foundry & Mfg. Co. Inc.

Ed—It is suggested that the author of the article, "Researchers Finding Many New Uses for Lithium", Dr.

Now you can have Far-Air® Filters . . .



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Farr Engineers will help you to properly solve your filter requirements. Write for literature . . . FARR COMPANY, 2615 Southwest Drive, Los Angeles, California.

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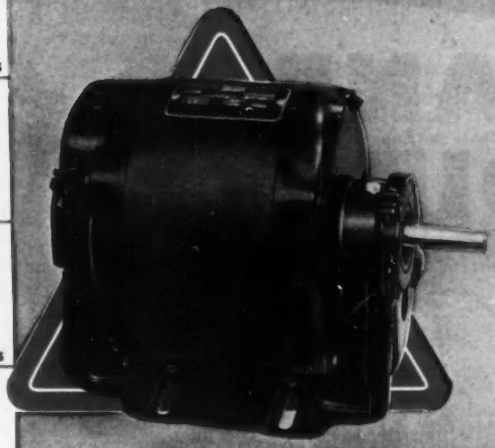

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Good motors are the best assurance of good service from appliances. Every year, Delco motors prove their durable quality on millions of appliances.

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It is easy to understand why more and more manufacturers are turning to Delco—the best running mate your product can have.

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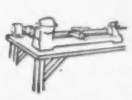
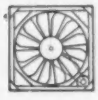
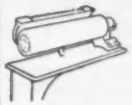

HOME WORK SHOPS


FANS (Ventilating)

DISHWASHERS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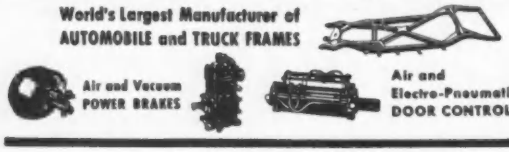

R. A. Lubker of Armour Research Foundation, may be able to give you all the essential information on the use of lithium as a deoxidizer for nonferrous castings. He certainly will be able to quote for you the references to this in the engineering literature and perhaps expand on some work done at Armour.

Although a copy of this letter is being sent to Dr. Lubker in the hope that he can help you out, it is urged that you write to him directly, giving him a few more details about your problem. His address is: Dr. R. A. Lubker, Asst. Chairman, Metals Research, Armour Research Foundation, 55 West 33rd St., Chicago, Illinois.

French Surface Gages

To the Editor:

In the January issue of your magazine on page 118 and 119, there appeared a series of pneumatic surface gages manufactured by Eteliers de Normandie of Paris, France.

We are interested in a device similar to the Type S adjustable tolerance device shown on page 118, and would like to know if they are available through a distributor in this country.

If they are not available in this country, additional information on the Eteliers de Normandie Company would be appreciated.

—J. K. BOUGHTON
The Goodyear Tire & Rubber Co.

Ed—It is believed that it is best to write directly to the manufacturers: Ateliers de Normandie, 12 bis. Place de Laborde, Paris 8, France.

Adhesive Bonded Structures

To the Editor:

We were much interested in your article, "Why Consider Adhesive Bonded Structures?", appearing in December, 1950 issue on page 138 thru page 143. On page 139 you have a table listing tradenames and manufacturers. We should like the address of Ciba Products Corp. the manufacturer of "Araldite"; Narmco Inc., the manufacturer of "Metlbond" and U. S. Stoneware Co. the manufacturer of "Reanite"—E. W. ZINGSHEIM
Spicer Manufacturing

Ed—The addresses of the companies mentioned in the article are: Narmco, Inc., 930 W. Grape St., San Diego, Calif.; Ciba Products Corp., 631 Greenwich St., New York 10, N. Y.; U. S. Stoneware Co., 5300 E. Tallmage Ave., Akron, Ohio.

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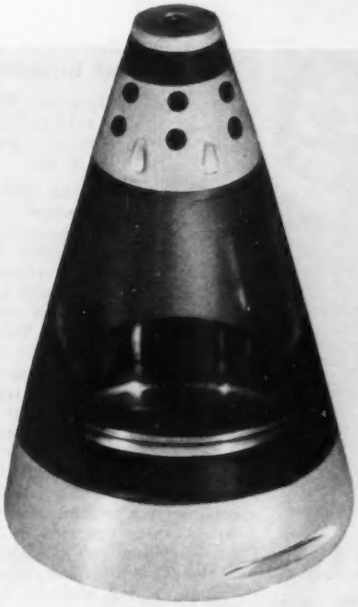
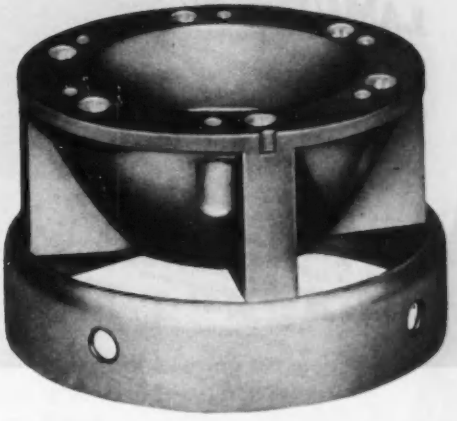


PROXIMITY FUSE HOUSINGS with exacting tolerances. (Left) Prolon injection-molded conical housing of ethylcellulose. (Below) Prolon compression-molded housing of mineral-filled, phenolic material.



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NEW BOOKS

Ingenious Mechanisms for Designers and Inventors

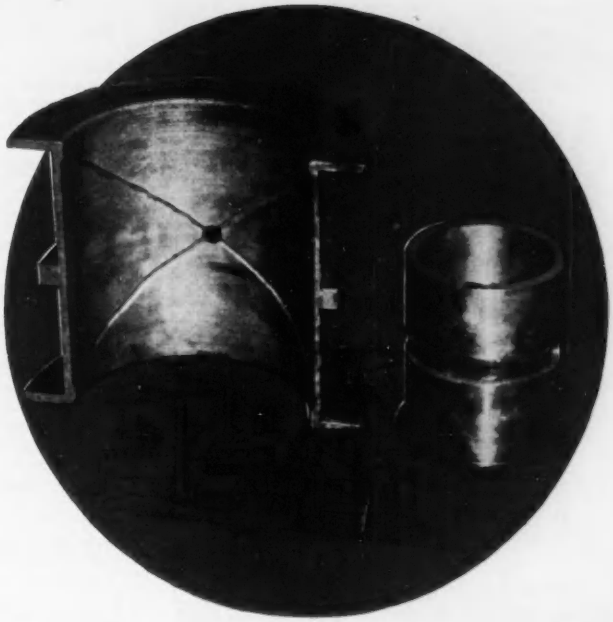
HOLBROOK L. HORTON, *Editor.* 536 *pages,* 6 x 9 *in. Published by The Industrial Press,* 140-148 *Lafayette St., New York* 13, *N. Y.* $6.

This is a companion book to Volumes 1 and 2 of the work "Ingenious Mechanisms for Designers and Inventors," previously published. Each volume is a self-contained reference work, the combined set forming a comprehensive encyclopedia of mechanical movements. The use of Volume 3 in conjunction with Volumes 1 and 2 has been facilitated by grouping mechanisms of the same general types under comparable chapter headings. For example, Chapter 2 of Volume 3 contains descriptions of some twenty gear and cam mechanisms for producing intermittent motion that are all different from, but perform functions similar to, those described in Volumes 1 and 2 under a similar heading.

The eighteen chapters or sections in Volume 3 deal with the following subjects: Cam Applications and Special Cam Designs; Intermittent Motions from Ratchet and Geneva Mechanism; Overload, Tripping, and Stop Mechanism; Locking, Clamping, and Locating Devices; Reversing Mechanisms of Special Designs; Reciprocating Motions Derived from Cams, Gears, and Levers; Crank-Actuated Reciprocating Mechanisms; Variable-Stroke Reciprocating Mechanisms; Mechanisms which Provide Oscillating Motion; Mechanisms Providing Combined Rotary and Linear Motion; Speed-Changing Mechanisms; Speed-Regulating Mechanisms; Feed-Regulating, Shifting, and Stopping Mechanisms; Automatic Work-Feeding and Transfer Mechanisms; Feeding and Ejecting Mechanisms for Power Presses; and Miscellaneous Mechanisms.

Of special interest is the chapter on hoppers and hopper selector mechanisms for automatic machines. Numerous types of hopper designs are described, including the center-board type, tube and rotary types, barrel type, tray type, vibratory type, and an ingenious magnetic design. Among the selectors are a spring-actuated pin type, a circular-blade type, a magnetic type, a selector for flat, hooked parts, a cup selector, and selectors for reversing the position of parts.

The illustrations and descriptions in



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this book are confined to important elements or units that may be applied to various types of automatic machinery and other mechanical devices. This eliminates the necessity of reading through lengthy and irrelevant descriptive matter. The mechanisms described have been effectively used in industry to perform the functions under which they are classified. Machine designers faced with a particularly difficult mechanism design problem will find many adaptable ideas among the mechanisms described. Conversely, designers who have worked out a tentative solution to their mechanism problem may find a simpler, less expensive mechanism described which will perform the same function. The set of three volumes comprises a total of 1610 pages and 920 illustrations of different mechanisms.

Achievements In Optics

A. BOUWERS. 135 *pages,* 6 x 8 *in. Published by the Elsevier Publishing Co., Inc.,* 215 *Fourth Ave., New York* 3, *N. Y.* $2.

This monograph surveys the work on optics in the Netherlands immediately before and during World War II. Part of the topics discussed have been published abroad, but have not yet appeared in the English speaking countries. Part of the work referred to was carried out secretly and the achievements purposely were not disclosed during the German occupation.

Fields surveyed by the author include: New optical systems, new optical instruments, geometrical optics, and physical optics.

Included in the topics presented are descriptions and discussions pertaining to mirror systems, the Schmidt camera and its aberrations; new microscopes, new telescopes, and new cameras; geometrical methods in optical design, researches on aberrations, luminosity of optical systems; the diffraction theory of aberrations, and phase contrast.

Calculus and Analytic Geometry

C. E. HOLMES *professor of mathematics at Bowdoin College, Brunswick, Maine.* 416 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co.,* 330 *W. 42nd St., New York* 18, *N. Y.* $4.75.

As a result of several years of work, this book has been prepared to serve a two-fold purpose. The first five chapters are arranged to extend over one semester; it simply introduces the

basic concepts of integral and differential calculus which would be of interest to liberal arts students. For the engineering student, succeeding chapters delve further into the techniques of differentation and integration and apply them to a variety of problems. The final chapters cover infinite series, ordinary differential equations and differential and integral calculus of multiple variable functions.

Following each chapter is a series of review exercises which could be used to emphasize the topics as they are studied. At the end of the book is a list of answers for certain problems which should prove useful.

Problems in Engineering Drawing

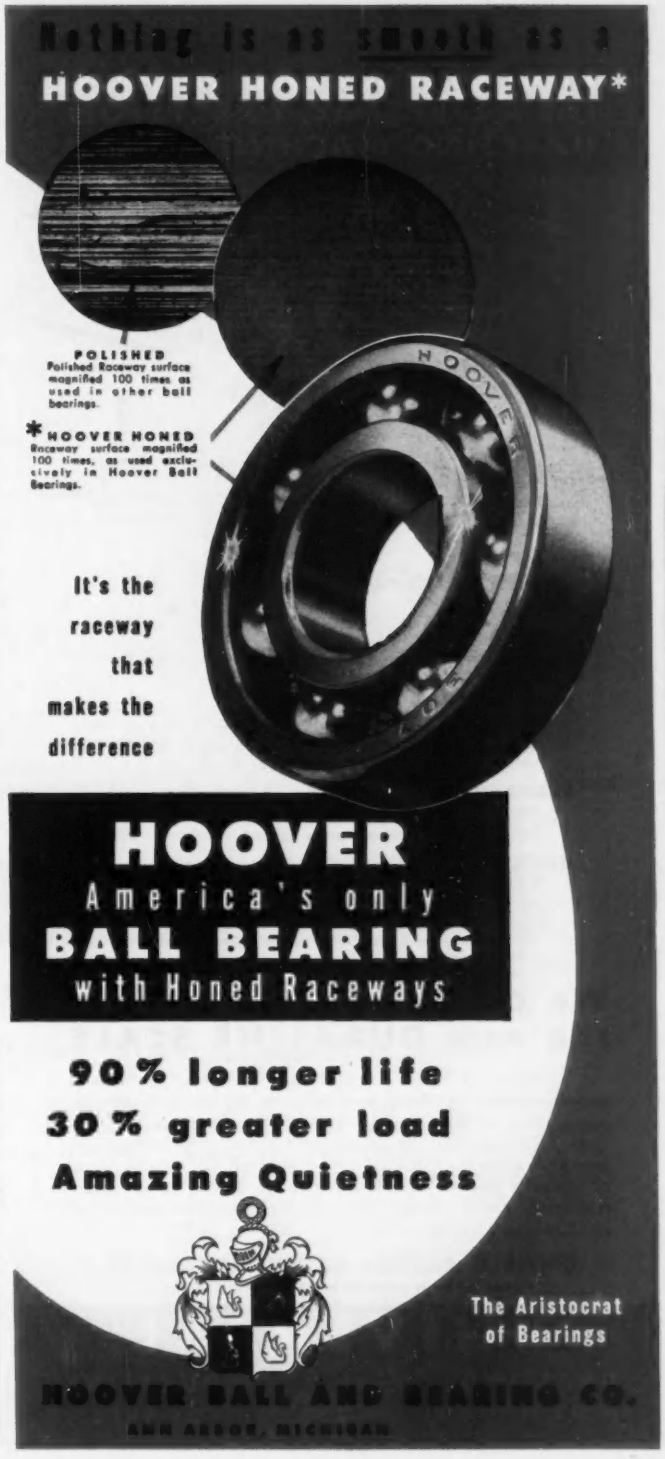
A. S. LEVENS, *Professor of Engineering Design, University of California and* A. E. EDSTROM, *Instructor, City College of San Francisco. New Edition, Series* III. 145 *pages,* 8½ x 11 *in. Published by McGraw-Hill Book Co., Inc.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $4.

In this new edition, which is keyed to French's "Engineering Drawing", seventh edition, the authors have attempted to improve all the sections, but, in particular, they have strengthened the treatment of the subjects of dimensioning and freehand sketching. In addition, a new series of lettering sheets based on recommended American Standards Association practices replaces those of previous editions.

For each topic, for example, isometric drawing, there is a page of instructions that refers the reader to the associated section in French's and then outlines in detail what is to be done on each of the sheets that follow. Both the sheets and the page of instructions are perforated near the binding for easy removal.

In arrangement, the book begins with the elementary subjects of lettering, types of lines, geometrical constructions and identification of surfaces and then goes into the drawing of orthographic and isometric views both in freehand style and with instruments. Problems are handled in a variety of ways. In one group, the student is given 2 views and required to give a third or he may be given 3 incomplete views and asked to finish them. The last sections cover the more complex topics such as auxilliary views, sectioning, threads and fasteners and dimensioning.

Two useful sections follow the last of the drawing groups. One is a list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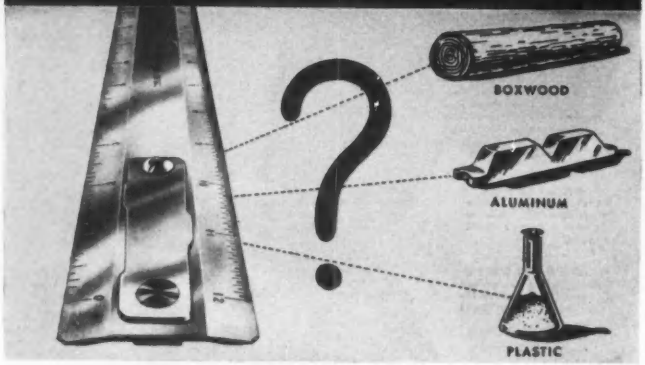

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Is material machinable to precision tolerances? Is material stable —will machined accuracy last?

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of visual materials, films, and sources through which they can be secured. The second is an outline of American Standard Drawings and Drafting Room Practice as prepared by the American Society of Mechanical Engineers and approved by the American Standards Association.

Guillet's Kinematics Of Machines

Revised by Austin H. Church, Professor of Mechanical Engineering, New York University, Fifth Edition. 300 pages, 5½ x 9½ in. Published by John Wiley and Sons, Inc., New York, N. Y. $4.

In revising this text book, Professor Church has endeavored to bring it up-to-date and to include more useful methods of analysis of linkages. For example, the problem of determining the velocity and acceleration curve scales has been simplified and a tabulation method is included for locating instant centers. A revised proof of Klein's Construction is given. Many inversions of the slider crank mechanism are also illustrated and discussed.

In the chapter on cams, the selection of the cam motion for specific applications is discussed along with an explanation of the methods of manufacture. The section on gears includes material on the generating principle of producing gear teeth which has replaced the method of formed milling cutters. The chapter on planetary or epicyclic trains has been amplified to include the tabular method of calculating the speed ratio. In addition, there is a discussion on the case of epicyclic trains where no gear is fixed but all are rotating.

Following each chapter there is a series of questions and problems which should prove helpful both to the student and instructor. At the end of the book are a series of miscellaneous special purpose mechanisms. As a summary, the final chapter consists of 29 drafting-room problems.

Industrial Electrochemistry

C. L. MANTELL, *Ph.D., Consulting Chemical Engineer. Third Edition, 781 pages, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y. $9.*

Electrochemical industries can be roughly divided into several classes: (1) those of an electrolytic nature, further subdivided into those of (a) the electroseparation type, represented by alkali and chlorine, (b) the elec-

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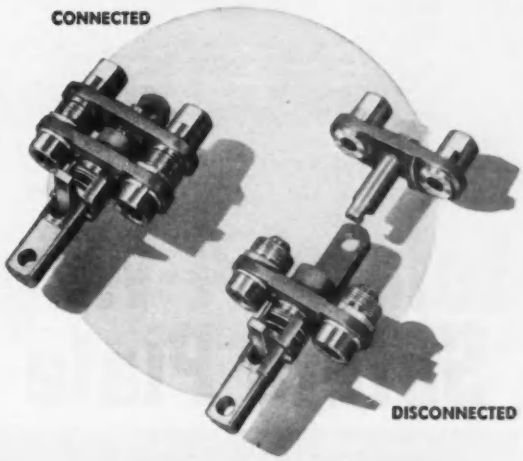

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trowinning type, as represented by the copper and zinc industries in which the metals are produced by the leaching of ore, (c) the electrorefining group, of which electrolytic copper and nickel are examples, and (d) the electrodeposition type, represented by the electroplating and electroforming field; (2) the fused electrolyte group, represented by aluminum, magnesium, and the alkali metals as examples; (3) the electrothermal group, examples of which are calcium carbide, cyanamide, graphite, and the synthetic abrasives; (4) the products of the electric furnace, which is used as a means of reaching elevated temperatures, such as the ferroalloys, electric steel, and special alloys; (5) the group which concerns itself with the conversion of chemical to electrical energy, as represented by the manufacture of batteries, of both the primary and secondary type; (6) a minor subdivision which, as the result of oxidation or reduction in electrolytic cells, is devoted to the production of inorganic and organic products; and (7) those industries in which the primary interest is concerned with the action of the electric current in effecting reactions and conversions in the gaseous phase. Each group and subdivision, and its problems and applications, are discussed in this book.

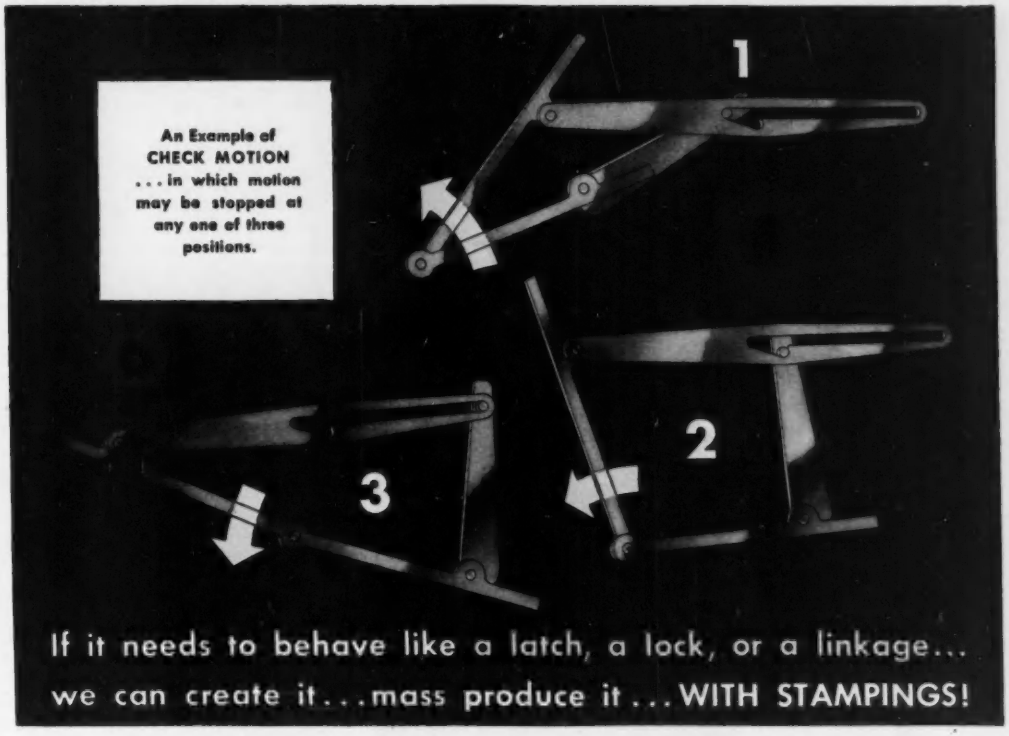
Die Design and Diemaking Practice

Edited by Franklin D. Jones, Third Edition. 1,083 *pages,* 6x9 *in. Published by The Industrial Press,* 140-148 *Lafayette St., New York* 13, *N. Y.* $7.

The material in the third edition of this book, just published, has been extensively revised. Five new chapters have been added, the cross-index expanded, and a detailed table of contents, listing important subjects in each chapter, has been provided to aid the reader in finding the information he needs.

The new chapters cover the following subjects relative to sheet-metal working dies: Materials Used in Diemaking; The Use of Rubber in Conjunction with Press Tools; Pointers on the Design of Stampings; and Heat-Treatment of Die Steels. A chapter on designing dies for powdered-metal parts has also been added.

The other twenty-one chapters in this edition deal with the following subjects: Dies for Cutting Blanks from Flat Stock; Methods of Determining Blank Diameters; Laying out Blanking Dies, and General Diemaking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2
3
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Practice; Punch and Die Details; Stops for Controlling Position of Stock; Sectional Punch and Die Construction; Blanking Dies for Rotor and Stator Laminations; Piercing and Perforating Dies; Sub-Press or Self-Guiding Dies; Action of Metal in Shearing and Wear of Cutting Edges; Bending and Forming Dies; Classes of Drawing Dies and General Designing Information; Dies for Drawing Shallow Cups or Shells; Dies for Drawing Deep Shells; Dies for Drawing Shells Having Wide Flanges; Drawing Dies for Conical or Tapering Forms; Deep-Drawing Operations on Conical-Shaped Parts; Drawing Dies for Spherical and Oval Shapes; Drawing Square and Rectangular Shapes; Expanding Dies of Rubber and Hydraulic Types; Dies for Special Operations; and Designing Dies for Inclinable Presses.

All designs illustrated and described in this book are the work of die design specialists, and have been successfully used in industry. The data presented on various phases of die-making practice and die materials represents a wide collection of costly die design experience in condensed, ready-reference form. Dies of the same general class are grouped together in chapters, and in some instances, as in the case of drawing dies, these general types are further subdivided for convenient study when comparisons of similar dies are to be made.

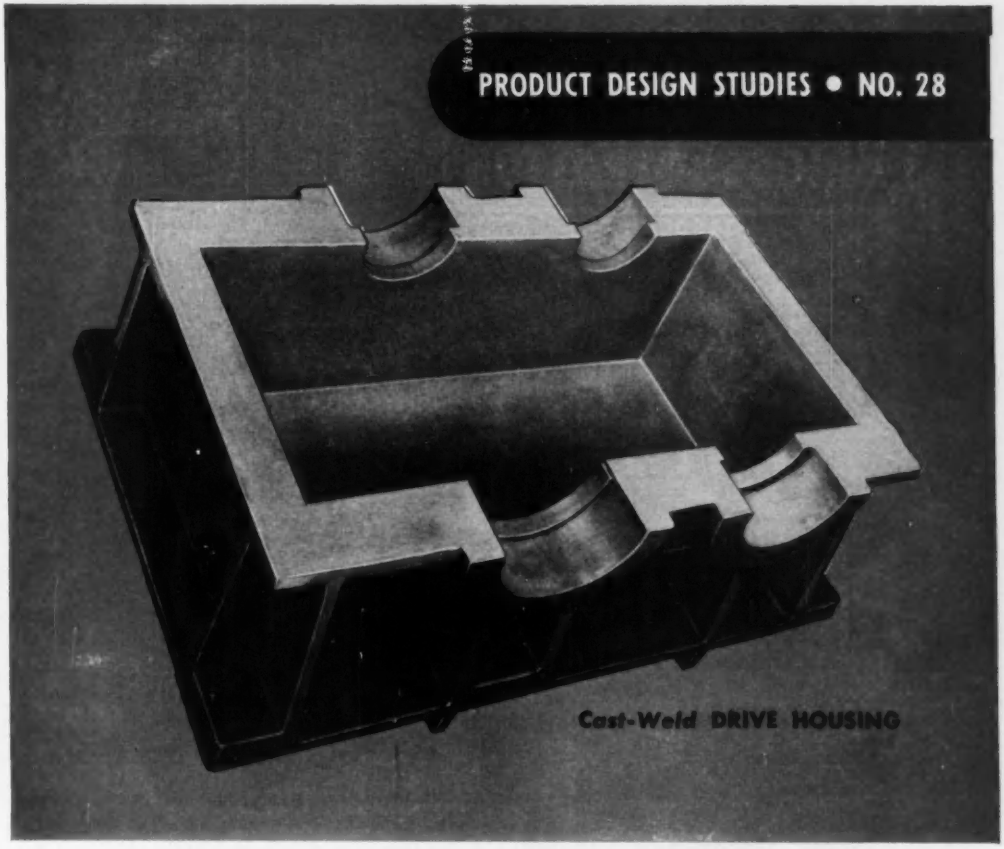
This treatise does provide an unusually comprehensive reference source and an eminently practical working guide for designers, diemakers, and tool engineers.

Cams And Springs For Poppet Valves

W. H. LEE. *Soft cover, 42 pages 7½ x 5 in. Published by Emmott & Co., Limited, 31 King St. West, Manchester, England.* $.35.

To increase the output of internal combustion engines and not appreciably alter the overall size and weight, present-day practice tends to increase the rotational speeds. One of the components affected by higher speeds is the valve gear, and the aim of this monograph is to provide a collection of data whereby the nature and intensity of the forces generated by the cam and the characteristics of the spring to control them can be accurately computed.

Only those cams commonly used are considered, together with a complete mathematical treatment of their velocity and acceleration. A graphical



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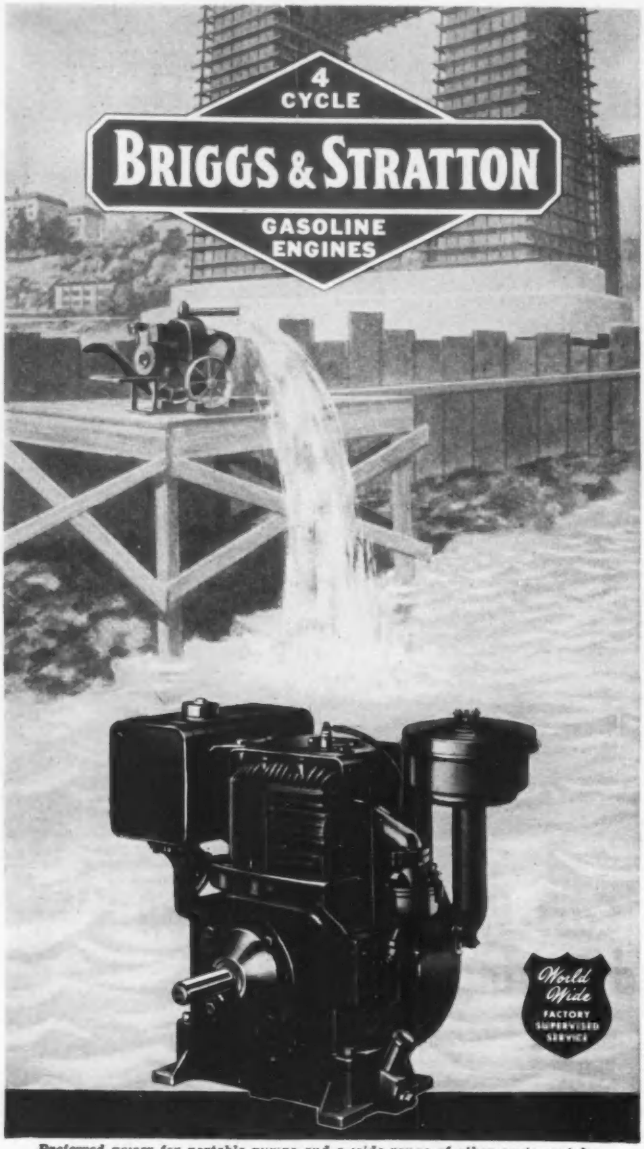

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method of determining these values is also included. It is applicable to any form of cam contour and will be found useful in the initial stages of design.

One unique feature of this study is the inclusion of a formula for the surging frequency of a spring by including the Wahl and Wood correction factors. The formula submitted gives five values that closely agree with those determined experimentally.

Papers on Radiography

A. S. T. M. Compilation of Papers. 98 *pages,* 6 x 9 *in. Published by the American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.* $1.75.

This symposium of papers has been compiled to correlate late developments in radiography. Six of the papers and discussions were presented at a session on Radiography at the Fifty-second Annual Meeting of the A. S. T. M., held in Atlantic City, June 27, 1949, which was sponsored by Committee E-7 on Non-Destructive Testing.

Specifically this compilation contains the following papers:

Recent Progress in Flash Radiography, by J. C. Clark.

10 Mev X-Ray Technique, by D. T. O'Connor, E. L. Criscuolo, and A. L. Pace.

Radiography and Autoradiography by Photo-electrons, by D. T. O'Connor and W. R. Maddy.

Mobilizing the Van de Graaff Generator for Precision Radiography, by E. A. Burrill.

A Universal Exposure Calculator for Radium Radiography and Its Application to Current Radiographic Films and Techniques, by N. A. Kahn, E. A. Imbembo, and J. Bland.

A Discussion of Radiographic Sensitivity, by C. H. Hastings.

A Revised Procedure for Establishing Radiographic Standards, by L. W. Ball.

An Investigation of Radiography in the Range from 0.5 to 2.5 Million Volts, by W. W. Buechner, R. J. Van de Graaff, H. Feshbach, E. A. Burrill, A. Sperduto, and L. R. McIntosh.

High-Speed Diesel Engines

P. M. HELDT, *formerly Engineering Editor of Automotive Industries, Sixth Edition.* 500 *pages,* 5 x 8 *in. Published by P. M. Heldt, Nyack, N. Y.* $6.

This book is not intended as a catalogue of the products of the Diesel

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industry, and no attempt has been made to mention or even describe all of the various makes of engines being built. The object has been to cover all of the more important principles made use of in the design of Diesel engines and their equipment, and to illustrate the application of these principles by brief descriptions of the current products incorporating them.

Relatively more space is given to American designs than in previous editions. Since the outbreak of the war, relatively little conspicuously new design work done in Europe has been released for publication. Before the outbreak of the war, the design of Diesel engines for army trucks was frozen in continental countries and the larger part of the industry there engaged itself in turning out standardized engines, with few radical design changes being attempted.

Problems connected with engine care and maintenance have increased with the expansion of the industry and a chapter on lubrication is included to fill this need. Another chapter covers supercharging, a practice that is receiving increased attention in connection with engines for railroad, marine and stationary applications. The chapter on aircraft Diesels formerly included has been rewritten and shortened because of the virtual design stagnation in this field.

This edition follows the previous one after an interval of less than three years. One of the ways it differs is that an Appendix has been added which covers recent developments in the field of Diesel engines. The Appendix contains statistics of engine production, an outline of progress in the various fields of applications, reviews of engineering papers on Diesel topics and brief descriptions of industrial products within the scope of this volume.

Among the difficulties being experienced in the operation of Diesel engines are excessive smoke in the exhaust under certain conditions and abnormal wear of cylinder liners. Both of these phenomena have been the subject of intensive study and some of the results obtained and remedies suggested are found in the digests of engineering papers included.

Torque Converters and Transmissions

P. M. HELDT, *Fourth Edition.* 476 *pages,* 5 x 8¼ *in. Published by P. M. Heldt, Nyack, N. Y.* $6.

For almost a decade, this book has served as a reference to designers con-

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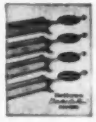

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The Bellows Air Motor illustrated is Model BEM5-25 (2½" bore, 2½" stroke). Other bore sizes are 1", 1¼" 2½", 3⅜" and 4½". Any stroke length. Model shown is equipped with the ELECTROAIRE VALVE for full electrical control. Air Motors with manually operated valves are also available.

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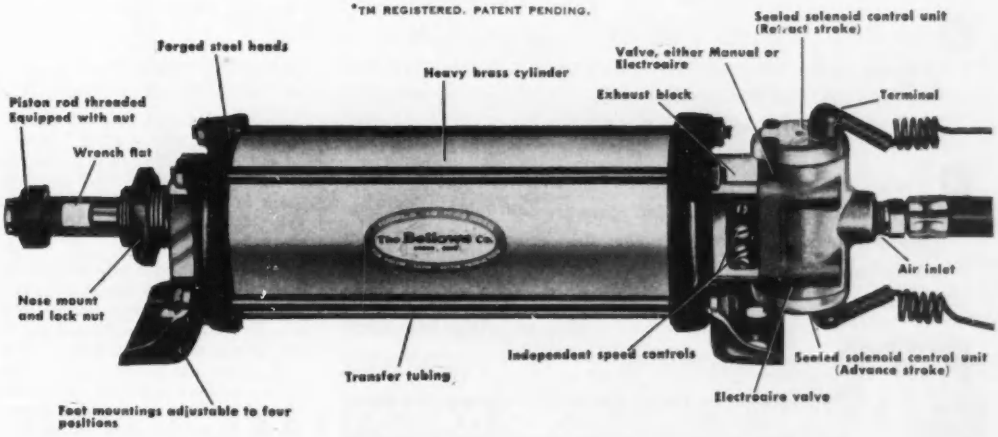

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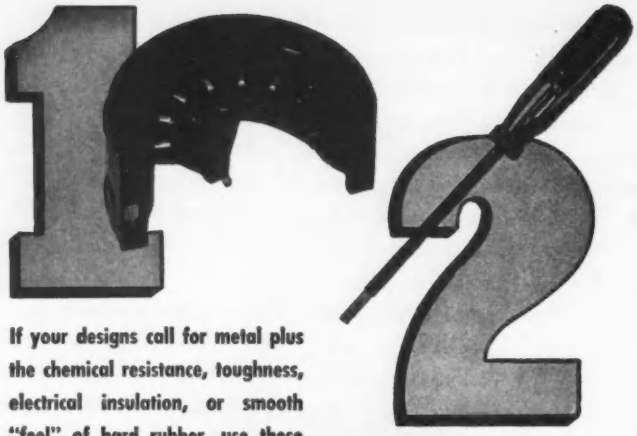

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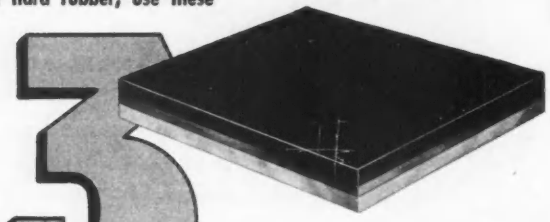

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fronted with problems in power transmission. Although it is primarily devoted to the applications of drives for internal combustion engines, there is a considerable amount of data and material which should prove useful for other applications. This fourth edition has been slightly amplified to include recent developments in automatic transmissions of some present-day cars. Construction details and operating characteristics of the Buick Dynaflow and the Packard Ultramatic transmission are discussed.

This book begins with a discussion of the importance of various gear ratios for power transmission. Friction clutches are explained along with sketches illustrating the design details of several types. Various automatic clutches are described: the centrifugal, vacuum and air-operated types. Included is a chapter on the design and performance of hydraulic couplings along with notes on the electric slip coupling. Details of several types of over-running clutches are shown and the problem of designing these clutches is covered.

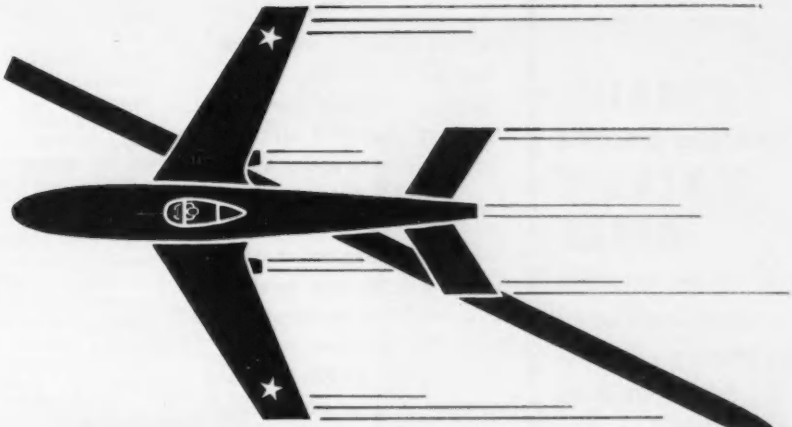
One of the most vital parts of any power transmission device is the gearing; this phase of design is discussed in great detail. Various factors of gear design are discussed such as: strength, wear resistance, tooth modifications, distribution of tooth load and special tooth proportions. This material should prove to be quite useful to the machine designer. In addition to describing various types of planetary gear trains there is a discussion on specific problems of designing such gear drives.

Finally there are chapters on hydrokinetic torque converters, differential transmissions, automatic and power controlled transmissions.

Statics and Strength Of Materials

JASPER O. DRAFFIN *and* W. LEIGHTON COLLINS, *Professors of Theoretical and Applied Mechanics, University of Illinois.* 398 *pages,* 6 x 9 *in. Published by The Ronald Press Company,* 15 *E. 26th St., New York* 10, *N. Y.* $6.50.

This book is specifically designed to meet the recognized need for an elementary text covering statics and strength of materials, usable and understandable by the many students in technical courses who do not expect to pursue a rigorous engineering curriculum of four or five years and who, consequently, do not carry their mathematics beyond college algebra and trigonometry. It is also suitable wherever it is



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found desirable to begin the study of mechanics before calculus has been completed.

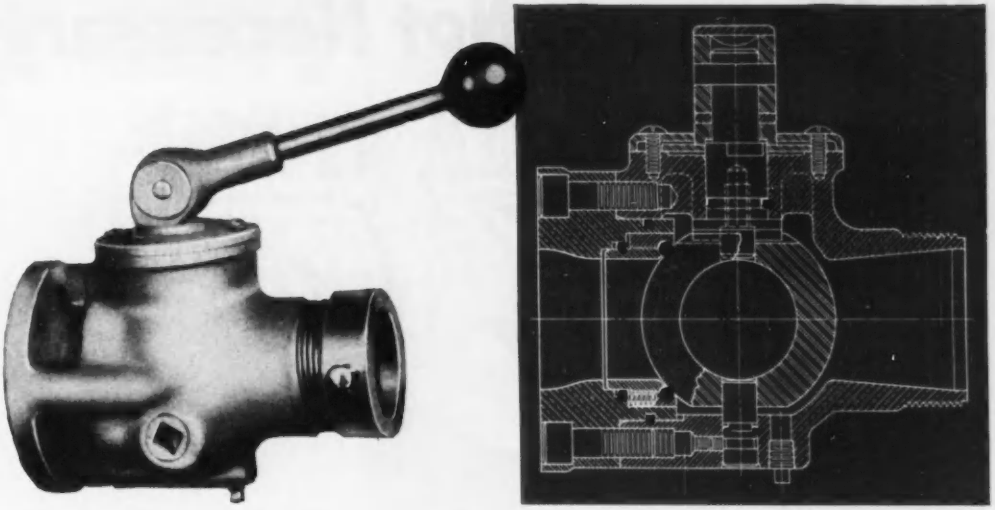
The distinctive and somewhat unusual combination of the two subjects in one volume results directly from these needs and purposes. In statics, coplanar force systems are treated in detail by the algebraic method, and a chapter is devoted to explanation of force systems in space. The strength of materials portion covers simple structural elements involving direct stress, including welded connections, torsion, bending, and column action. The subject matter includes almost all that which is commonly taught.

The methods of presentation make much use of free-body diagrams and emphasize the geometric interpretation and physical visualization of the problem rather than the purely mathematical consideration, yet with but few exceptions all equations are rigidly derived. Prominence is given to general principles and their application rather than to specialized equations. Explanations are given in detail and many illustrative problems are solved.

The equations for the deflection of beams have been derived by the repetitive, though at times laborious, method of finding the areas of the shear, moment, and slope diagrams. The repeated use of a single procedure, that of finding the area under a curve, has proved to be the method most easily understood. The properties of areas under curves and moments of inertia are treated by the integral calculus concept of algebraic summation within specified limits, with the integral form presented as a law which can be proved.

The subject of columns is presented in considerable detail in order to develop an adequate understanding of the behavior under load of both ideal and actual columns and not merely to become proficient in the use of empirical formulas. Many test data for various kinds of material in common use are presented by means of graphs and analyzed. As a summary, the working formulas for columns recommended by a number of specification writing organizations and large cities are tabulated.

A large number of problems are provided which have been selected from the broad fields of structures and machines. These problems range from those which are simple ones for drill purposes to the more difficult ones which require comprehensive analysis. Extracts from tables of trigonometric functions and properties of typical rolled steel and aluminum alloy sections are given in an Appendix.



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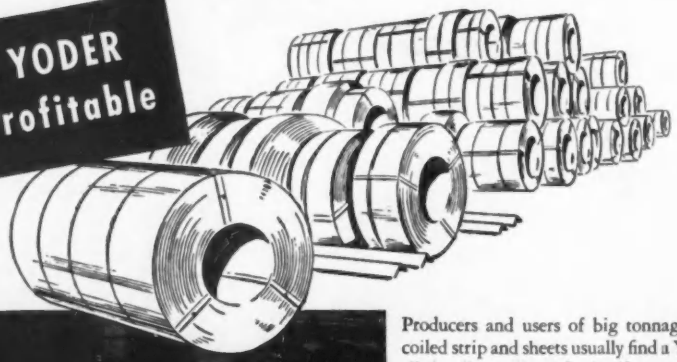

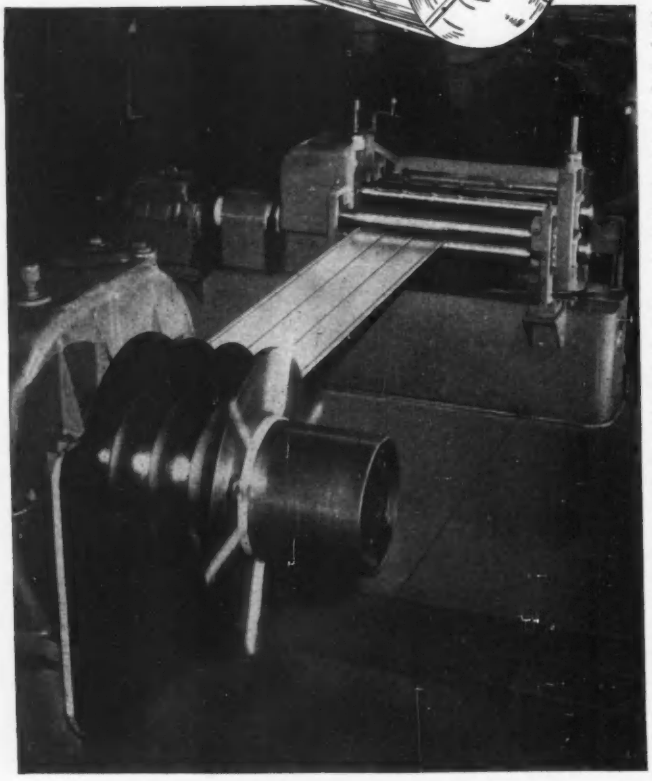

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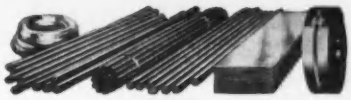

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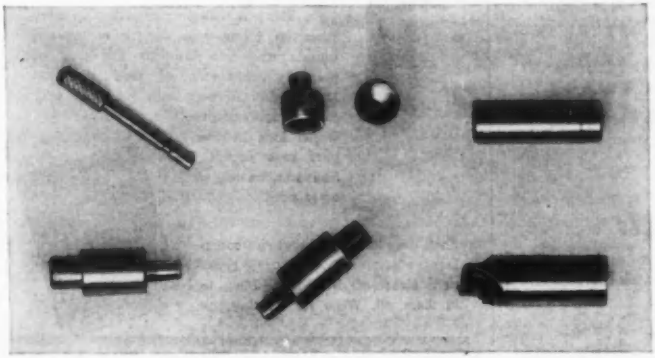

Parts made from free turning brass rod. Lower right shows trepanning tool used for adjacent parts.

Savings Often Made Through Restudy of Screw Machine Jobs

Restudy of many screw machine jobs, plus imagination, can often lead to substantial savings by elimination of secondary operations or reduction in cycle time.

One example of this reasoning is seen in the upper left of the illustration.

Method Reversed

The part, made from ⅛ in. dia. free turning brass rod, is 15/16 in. long with a 1/16 in. turned dia. ⅝ in. long. The stock size knurl is 5/16 in. long.

Originally the part was box turned, the undercut formed, fed out, knurled and cut off. The 3/64 in. dia. hole drilled in the knurled end was done as a secondary operation.

It was then decided to do the job in reverse to eliminate the secondary.

The end was first drilled and chamferred. After feeding out the part, the undercut was formed and the 1/16 in. diameter cut with a swing tool, supporting the part during these operations with a half-round support on the stock diameter. Next came the knurling and cutoff. The knurling is clean and sharp despite the full over-hang and the turned diameter is not distorted. The turned diameter is also more accurate than in the original cycle.

Double-purpose Spot Drill

The small knurled, formed and threaded parts in the center of the illustration are also of free turning brass rod. The 1/32 in. center hole runs through. To obtain as close concentricity as possible with standard drills, a spotting drill was used, going to a depth sufficient to leave a spot for the small, through drill after the flat-bottom tap drill was run in.

Trepanning Method

Trepanning operations, especially where close tolerances are involved, are often trouble spots despite the ease with which free turning brass can be cut.

Plunging tools are often used in the turret. However, what might be called a single-lip hollow mill is very satisfactory on small parts.

The parts, as well as the cutter, are shown in the bottom row of the illustration.

The through hole was drilled, the ⅛-in. diameter box turned, then the trepanning was done and the inside of the large diameter chamferred.

Combination Tool

The tool was turned in a lathe, hardened and ground. The center clearance was drilled and lapped. Since it was used as a support on the long turned diameter, some burnishing action was both expected and desired.

The depth of cut was ⅛ in. and the outside wall of the tube was only 1/32 in. Accuracy was necessary since another part mated with it.

Increase Tool Angles On Medium-Leaded Rod

Screw machine tools designed for free machining brass rod are often used by operators for turning medium leaded rod.

In many cases they will be satisfactory. However, due to the greater ductility of the medium leaded rod (1.8% lead as compared to 3.4% in free turning rod) difficulties through burrs and poor finishes are encountered. Often these troubles can be easily cleared up by increasing slightly the rake and clearance angles and lowering the turning speed. Many times, however, the changed tool angles will be sufficient with no lowering of speed and feeds.

As the chips do not break up as rapidly on medium leaded rod, it is necessary to have rake angles sufficiently great to carry away the chip rather than rolling it back on the stock.

The increased clearance angles will help to prevent rubbing in the more ductile alloy. (6289)

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Tyer technical knowledge and original thinking are available to you to make Rubber, *our* product, more useful to you in *your* product. The same know-how and resourcefulness that led Tyer to originate White Rubber and Elastic Webbing in the early days of the industry, have enabled Tyer, through war and peace, to supply American manufacturers with

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Here's a natural application for Driv-Lok Pins. Many satisfied customers are using them as hinge pins for doors, covers, guards and miscellaneous swinging or pivoted components of their products. Merely drill uniform hole, use pin with half - length grooves which lock in one part and permit free rotation of other part.

Each application suggests countless others. There are types and sizes of DRIV-LOK Pins to fit them all. Write for Catalog.

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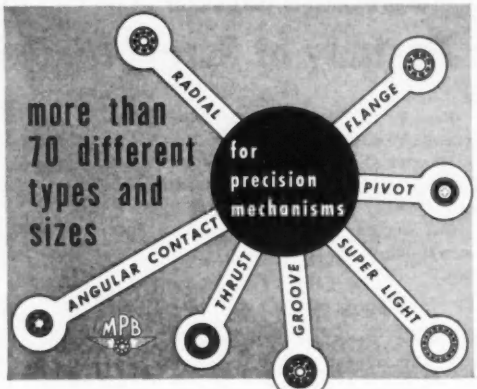

Complete specifications on more than 70 different types and sizes of miniature ball bearings for precision mechanisms presenting anti-friction, light weight, high load capacity, and other unusual conditions.

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NEW DRAFTING SHORT CUTS

Eliminate Costly Retracing

at INGERSOLL-RAND

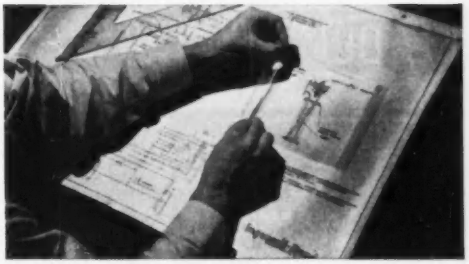
Phillipsburg, N. J.

"Ink quality" file copies of pencil drawings are produced with Kodagraph Autopositive Cloth

Instead of making expensive "ink on cloth" tracings of its original drawings, Ingersoll-Rand simply reproduces them on Kodagraph Autopositive Cloth. This new photographic material produces positive copies *directly* (like Kodagraph Autopositive Paper and Film) . . . without the negative step . . . without darkroom handling. No special equipment is required, either: a photocopy machine is used for the exposure operation . . . standard photographic solutions for development. *Result:* intermediates that have the sharpness, the sparkle of new ink tracings . . . with non-smudging, dense photographic black lines on a durable white cloth base.

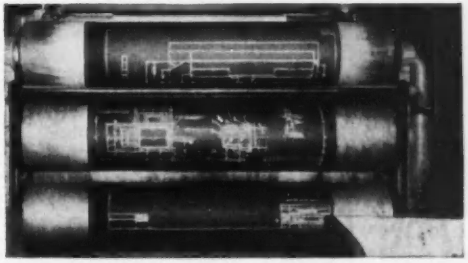
Old, soiled, or damaged drawings are restored with Kodagraph Autopositive Paper

When such drawings are taken from the files, the call is for Kodagraph Autopositive Paper—to eliminate hours of expensive retracing time. This low-cost, high-contrast photographic material increases line density . . . cleans up backgrounds . . . in many cases delivers serviceable intermediates that require no handwork at all. Drawings in very poor condition are restored by Ingersoll-Rand in the following manner: after an "Autopositive" is made, stains, creases, and other unwanted elements are removed with eradicator fluid or razor blade. Then, the print is used to produce a second "Autopositive," which is touched up with pencil if necessary.



Standard units are added to new drawings with Kodagraph Autopositive Film

Among the many ingenious drafting short cuts developed by Ingersoll-Rand is the use of Kodagraph Autopositive Film overlays made from standard-component drawings. These transparencies are kept on file . . . and taped to new drawings whenever necessary. Following this, the composite is reproduced on Autopositive Paper. *Result:* a photographic intermediate of uniform line density . . . plus important savings in drafting time.

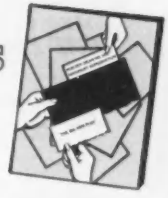


Additional advantages of using Kodagraph Autopositive intermediates

Sharper, cleaner blueprints are produced—at uniform, practical speeds—because Ingersoll-Rand makes them from "Autopositives" instead of its perishable original drawings. This way—there's far less chance of "reading errors" in the shop. And valuable originals are protected against machine wear and tear . . . constant handling; are kept safe in the files available for reference and revisions only.

Kodagraph Autopositive Materials

"The Big New Plus" in engineering drawing reproduction



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Learn in detail how you can use Kodagraph Autopositive Paper, Cloth, and Film — the revolutionary products which you, or your local blueprinter, can process quickly, economically. *Write today* for a free copy of "Modern Document and Drawing Reproduction."

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Industrial Photographic Division
Rochester 4, N. Y.

Gentlemen: Please send me a copy of your illustrated booklet giving all the facts on Kodagraph Autopositive Materials.

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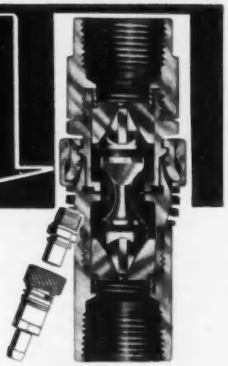
6 REASONS why American industry specifies **WIGGINS**



★ *Craftsmanship*
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★ *Uniformity*
★ *Low pressure drop*
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Over many years, Inst-O-Matic has acquired a value far above its mere mechanical qualities, a value proved by its acceptance throughout industry and in all branches of the armed services.

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Users' experiences prove conclusively that this design stands up longer under extreme pressure and vibration, and rarely requires replacement. Inquire today.

Basic Sizes; ¼", ½", ¾"; intermediate sizes where needed. Unconditionally guaranteed leak proof from zero to maximum recommended pressure.

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For proof of performance, write for name of nearest representative to E. B. WIGGINS OIL TOOL CO., INC., 3424 E. Olympic Blvd., Los Angeles 23, Calif.

LASTS TWICE AS LONG ...STILL GOING STRONG

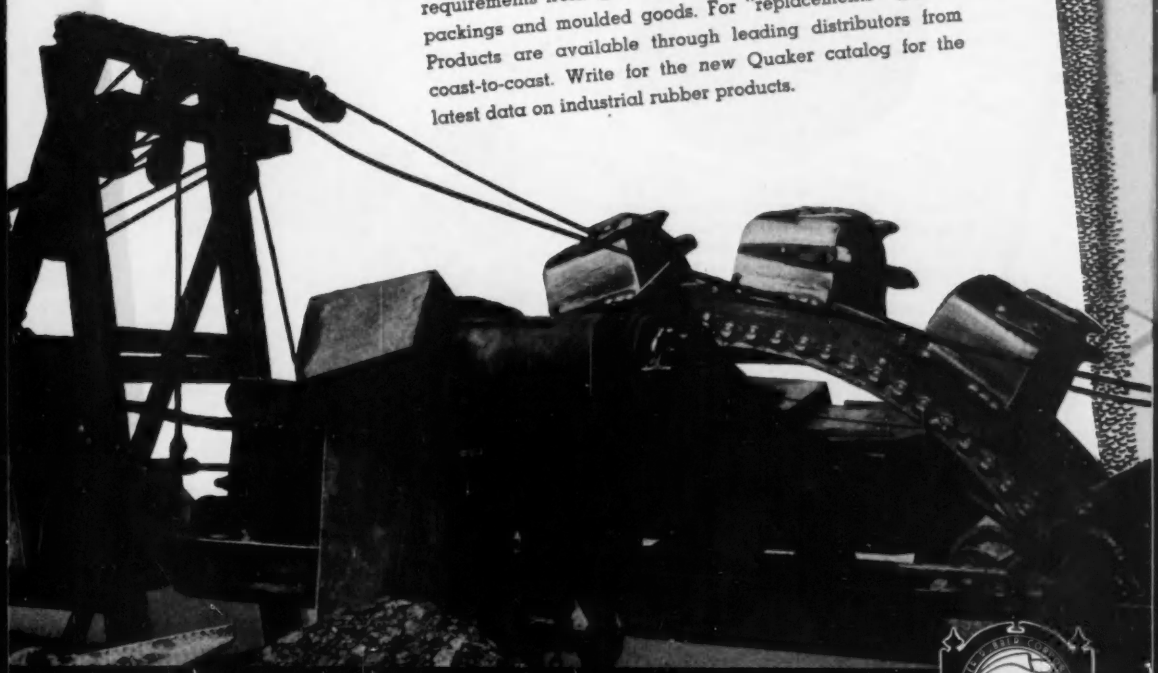
QUAKER CONVEYOR BELTING

LASTED LONGER THAN ANY OF SIX OTHERS

A "belt-killing" drive on a well-known trench digging machine was wearing out conveyor belts in a matter of weeks or months. Then a Quaker "Pre-Tested" Conveyor Belt was installed. Result . . . belt lasted almost twice as long as any of the six different belts used . . . still going strong . . . in fine shape.

Performance records like this and thousands of others are making more and more design engineers specify Quaker Industrial Rubber Products as original equipment.

Quaker sales engineers can assist you in producing a new rubber product . . . or applying an existing one to meet your requirements from Quaker's complete line of belting, hose, packings and moulded goods. For "replacements" Quaker Products are available through leading distributors from coast-to-coast. Write for the new Quaker catalog for the latest data on industrial rubber products.



QUAKER RUBBER CORPORATION

DIVISION OF H. K. PORTER COMPANY, INC.

PHILADELPHIA 24, PENNA. BRANCHES IN PRINCIPAL CITIES

What's U. S. Rubber doing to bridge the gap between hard and soft rubber?

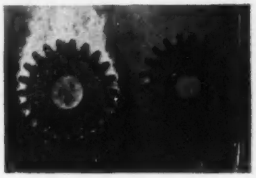
Washing machine parts, formerly made of plastic and metal, now made of new thermosetting plastic, Enrup, which has higher abrasion resistance and is structurally stronger.

The new "U. S." thermosetting plastic, Enrup, can be made flexible and elastic as soft rubber, or rigid as hard rubber. Enrup offers entirely new possibilities to design engineers. The washing machine parts, shown above, are made of Enrup because its abrasion resistance and structural strength are greater than the combination of metal and plastic formerly used.

Enrup can be made into almost any shape or form, simple or complex. It can be punched, sanded, sawed, nailed, bolted, molded and machined. Perhaps Enrup is just what you've been looking for to improve your product or your manufacturing operation.

For more details, write to address below.

Some of the products made of Enrup for leading manufacturers. The smallest items weigh as little as one-third of an ounce. Engineers often find Enrup cuts molding costs, permits operating economies hitherto impossible.



Note how a bath of 20 percent solution of sulphuric acid eats away the steel gear at left, while the Enrup gear is unharmed. Enrup is non-conductive, non-absorbent, easy to clean, is noiseless.

PRODUCT OF U.S.RUBBER SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

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He's the Handy & Harman field service engineer. You'll like him because he really knows his stuff. He was hand-picked and specially trained for the job. He is a friendly chap with a wide background of experience that covers both domestic and war time production. He loves to take off his coat and get his hands dirty — and he's an artist with a torch. Give him a brazing problem and he's a bulldog — he'll never let go until it's licked. And if it's too tough to lick on the spot, he's backed by the top-ranking and most experienced Research and Engineering staffs in the business — originators of the well known low-temperature silver brazing alloys EASY-FLO and SIL-FOS. He's ready and eager to give you the following services — without cost or obligation.

DEMONSTRATIONS — of silver alloy brazing in your own shop.

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ENGINEERING AID — to assure correct joint design and most effective application.

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TECHNICAL BULLETINS — making available the technical facts and data on silver alloy brazing as developed in our Research Laboratory.

CALL OR WRITE — the nearest office listed below and say when you would like a field service man to call.

HERE'S THE BULLETIN to give you full facts

This new 28-page Bulletin 20 gives the whole remarkable EASY-FLO and SIL-FOS brazing story — including useful information on joint design and fast heating and production methods. It's a "must" for all who design or produce metal assemblies. Write for a copy today.

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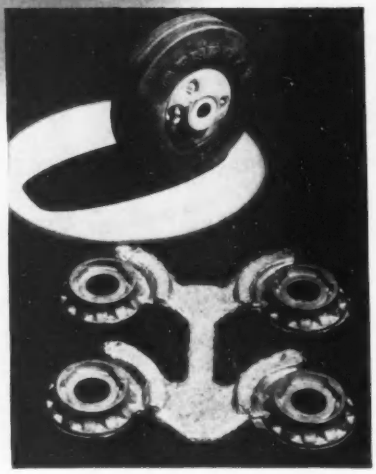

This Well-Cast magnesium permanent mold wheel casting—a ¼ lb. light weight—reduces the overall weight of the hand truck on which it's used. Tough as an American in Korea, it's also a push-over to machine. Same thing applies to our sand castings in either magnesium or aluminum. Want to lose some weight?

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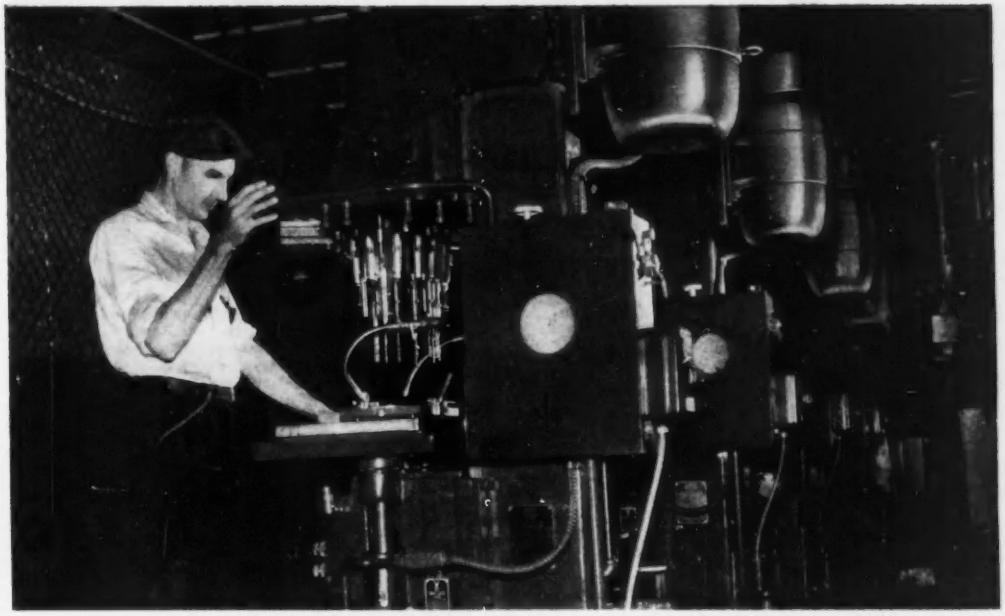
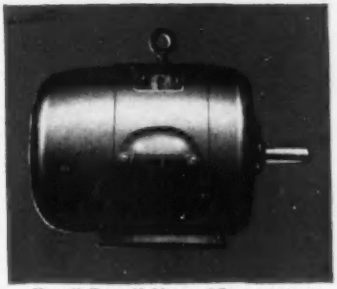
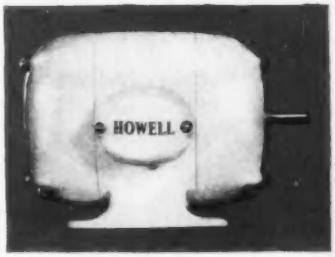


Howell totally enclosed motors power these multiple drill spindles in the plant of a leading auto maker.

HOW MUCH ARE ELECTRIC MOTORS WORTH?



Howell Type K Motor. Offers constant performance in the presence of dirt, dust, fumes and moisture. Sizes from 3 to 150 H.P. at 1800 R.P.M. Either vertical or horizontal mounting.



Howell Sanitary Motors meet the most exacting standards of the dairy and food industries. They contain no pockets, cracks, or crevices. Available for vertical or horizontal mounting.

The actual cost of the motors you see pictured here amounts to hundreds of dollars.

But their true worth, in terms of supplying the power for these multiple drill spindles to turn out finished parts, runs into thousands.

It's tough applications like this which prove the real value of Howell Industrial Type Motors. For your jobs, Howell serves three ways: (1) by engineering electric motors to your job; (2) by furnishing motors of the highest quality; (3) by serving you after the sale.

May we apply our facilities and engineering ability to your problems?

HOWELL ELECTRIC MOTORS COMPANY

Howell, Michigan

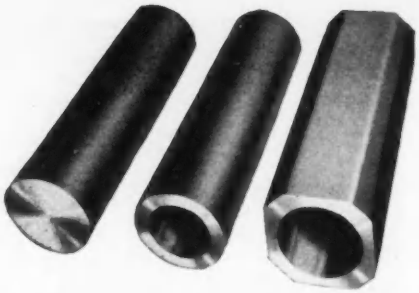
HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

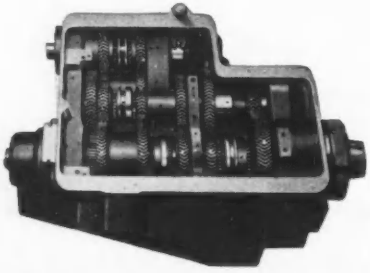
Precision-built industrial motors since 1915

Tumbling Barrels . . to Resist Corrosion and Abrasion. These barrels are subject to extreme wear from small parts being cleaned by the swirling agitation of caustic solution and abrasives. For extra-long life, they are fabricated from wear- and corrosion-resistant Ampco Grade 8 sheet, carbon-arc welded with 5/32" Ampco-Trode 160 coated electrodes used as filler rods.



Ampco Extrusions available as solid rod and/or tube in rounds or simple shapes. From Ampco's own 2275-ton hydraulic press and extrusion mill. Their use saves metal, machining time, and costs. Superior grain structure and exceptionally high strength are assured — *plus* close tolerances and good surface finish.

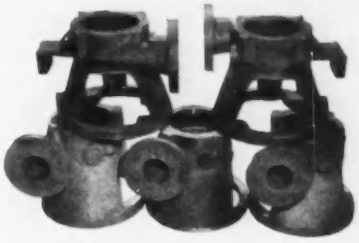
Ampco Metal Cam . . . for Smooth Action, Extreme Wear-Resistance. Ampco Grade 20 selected because it actually outlasts hardened steel with twice the Brinell hardness. This is due to its extreme wear-resistance and the smoother action of bronze against steel. Also ideal for rollers, gibs, slides, wearplates, forming dies on light-gauge steel and welding jaws.



Ampco Bushings on High-Speed Headstock . . . for High Wear-Resistance. There are 16 Ampco Grade 18 Bushings in this one headstock: 14 on loose-running gears, 2 on the center bearing of the intermediate shaft and main spindle. Ampco Grade 18 chosen as ideal alloy because of the heavy gear loads and high spindle speeds. Extra life assured by high tensile (77-85,000 psi), and Brinell hardness of 159-183.

Stock Bars of Grade 18 Ampco Metal . . . for Production and Maintenance where long life is important. Wear-resistant. Have exceptional impact and fatigue characteristics. Centrifugally cast to provide dense, fine grain structure free from impurities. Readily machinable. Ideal for bearings, bushings, gears, worm wheels, slides, guides and other wear applications. Available from stock in 12½-inch lengths from 2½-inch to 6-inch OD, or solid bars ½" to 4½" diameter, cut to desired lengths.

Paper Mill Rolls . . Wear-Resistant for Longer Service. Weight and wear are the usual problems in such rolls. Both were licked in this case — with Ampco aluminum-bronze. Centrifugally-cast Ampco Metal Grade A-3 provided a light, hollow roller — resistant to both wear and corrosion. Shaft and end-plates were cast of the same alloy and welded to the roller with corrosion-resistant Ampco Trode 10 electrodes.



Cast Ampco Metal Pump Bodies . . . for Corrosion-Resistance. Ampco Grade 12 selected for its high resistance to corrosion and wear (which is a special quality of all Ampco Metals). Grade 12 also has the advantage of quick, easy sealing for valve and pump parts. Meets Federal specification QQ-B-671a, Class A, and Navy specification 46-B-18c.

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Equipment Life--Lower Costs with AMPCO Bronze Parts

Specify Ampco aluminum bronze for these unique, money-saving properties:

1. High tensile strength
2. High compressive strength
3. High impact and fatigue values
4. Excellent bearing qualities
5. High "strength to weight" ratio
6. Resistance to wear and corrosion
7. Good retention of values at temperature extremes

It pays to use Ampco aluminum bronzes wherever you can. These long-wearing bronze alloys assure longer life and better service for almost any part — reduce maintenance and replacement frequency, cut downtime losses to a minimum!

First of all, be sure to specify Ampco bronzes for your own products. They're a mark of extra-quality which all buyers recognize. By the same token, look for Ampco bronze parts as a mark of extra-value in the equipment which you buy. And of course, use Ampco bronze replacements in your own plant maintenance to reduce downtime, service and repairs, and to insure low-cost, trouble-free operation.

Make Ampco Bronze Parts a "must" in every plan — product or production. That way you're sure of lower costs. Send for complete information today.

Ampco aluminum bronze and other Ampco copper-base alloys are available in a variety of grades to meet your exact requirements in any form you need: rolled sheet or plate, sand or centrifugal castings, forgings or extrusions, arc- and resistance-welding electrodes, and corrosion-resistant centrifugal pumps and plug valves.

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Until now, General American's Plant No. 1 was one of the most modern and versatile plants in the plastics industry . . .

Now, the opening of the new Parrish Ave. Plant combined with Plant No. 1 gives General American facilities unmatched anywhere.

Parrish Ave. specializes in injection molding. Presses range from 48 oz. to 300 oz. An overhead crane supplies materials. Continuous conveyors take the finished products away. Reinforced plastics molding is also housed there.

With Plant No. 1 (2 oz. to 48 oz. injection; 100 to 2,000 ton compression; low pressure molding; painting and metallizing)—an impressive tool shop—and these new facilities—you'll find General American your one complete source for plastics molding.

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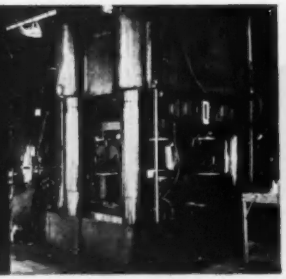

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DIE-MAKING

for civilian and for defense production....

PLASTICS DIVISION • GENERAL AMERICAN TRANSPORTATION CORPORATION

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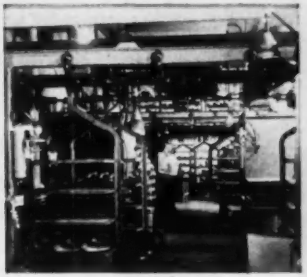
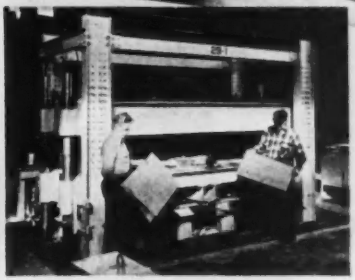


PAINTING



48" x 144" LOW PRESSURE MOLDING of reinforced plastics supplemented by smaller presses.

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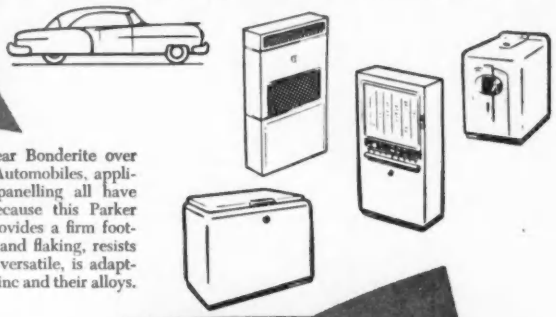
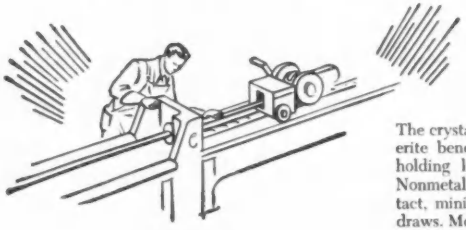
To anchor paint, preserve fine appearance



The best looking paint jobs wear Bonderite over the metal and under the paint. Automobiles, appliances, metal furniture, metal panelling all have longer lasting paint finishes because this Parker corrosion resistant paint base provides a firm foothold for paint, prevents peeling and flaking, resists rust and corrosion. Bonderite is versatile, is adaptable for use on steel, aluminum, zinc and their alloys.

To make drawing smoother, easier

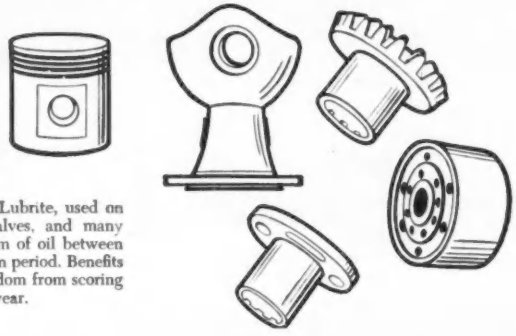
BONDERITE



The crystalline phosphate coating created by Bonderite benefits drawing and forming operations by holding lubricant even under extreme pressures. Nonmetallic Bonderite prevents metal-to-metal contact, minimizes galling and scoring, allows deeper draws. Metal polishing costs are reduced by treating with Bonderite before forming.

PARCO LUBRITE

To resist wear on friction surfaces

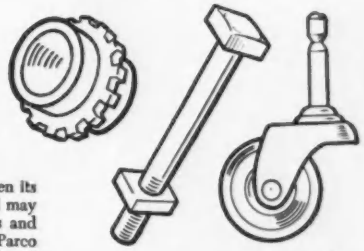


Oil absorbent, nonmetallic Parco Lubrite, used on pistons, cylinder walls, gears, valves, and many other bearing surfaces, holds a film of oil between moving parts in the critical break-in period. Benefits are faster, smoother break-in, freedom from scoring and scuffing, longer subsequent wear.

for metal treatment and metal finishing

PARCO COMPOUND

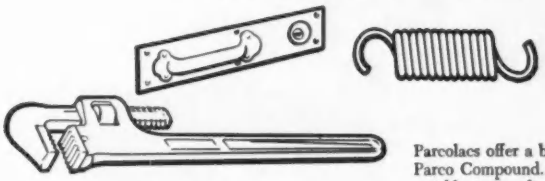
For effective rust resistance



For a third of a century, this product has given its protection to iron and steel. Parco Compound may be used on wrought iron, stampings, castings and sheets. It stoutly resists rust and corrosion. Parco Compound is simple to use, easy to control and economical.

For excellent special finishes

PARCOLAC



Parcolacs offer a broad line of finishes for use after Parco Compound. Among them are stains that dry quickly to a soft, matte black which is handsome, long-wearing and easy to handle and apply. Other specialized finish requirements find their answer in Parker Parcolacs.

PARKER PRODUCTS MEET GOVERNMENT SPECIFICATIONS

SPECIFICATION	PARKER PRODUCTS
JAN-C-490, Grade I	Bonderite 100, 125, 140, 160, 170, 180
JAN-C-490, Grade II	
Type 2	Parco Cleaners 341, 350, 371
Type 4	Parco Cleaners 250 and 260
Type 5	Parco Cleaners 210 and 220
Type 6	Parco Cleaners 100, 101, 110
JAN-L-548	Parco Compound—Parco Powder
U.S.A. 57-0-2	
Type II, Class A and Class A1	Parco Lubrite 1, 2, 3
Type II, Class B	Parco Compound—Parco Powder
Type II, Class C	Bonderite 32, 34, 100, 125, 140, 160, 170, 180
U.S.A. 50-60-1C	Bonderite 100, 125, 160, 170, 180
U.S.A. 3-213	
Type I	Parco Cleaner 250
Type II	Parco Cleaner 260
AXS 1245	See JAN-C-490
QQ-P-416 Type III	Bonderite 32, 34
Navy Aeronautical M-364	Parco Compound—Parco Powder

PARKER RUST PROOF COMPANY
2179 E. Milwaukee • Detroit 11, Michigan

WANT MORE INFORMATION?

Call or Write Today!

Parker Rust Proof Company
2179 E. Milwaukee, Detroit 11, Michigan

Please send me complete information on the Parker Products indicated below:

☐ Bonderite ☐ Parco Lubrite ☐ Bonderite as an aid in drawing
☐ Parcolacs ☐ Parco Compound ☐ Gov't. Spec. No. _____

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FRACTIONAL FRAME SIZES IN STANDARD OR SPECIAL* DESIGNS!

* Motors shown have special adapter, special shaft. Eccentricity of machined face with respect to shaft held to very close tolerance by taking qualifying cut after motor is completely assembled.

GRAHAM TRANSMISSIONS INC. selected this complete line to motorize its widely-used variable speed transmissions. Starting with one frame size only, Graham has been a steady user of Doerr motors for many years.

Many other leading machinery builders continue to place their confidence in Electro Machines products and service as proved by the high percentage of repeat orders.

If you have a particular motor problem please let us hear from you.

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DOERR MOTORS

Standard or Designed to Your Specifications

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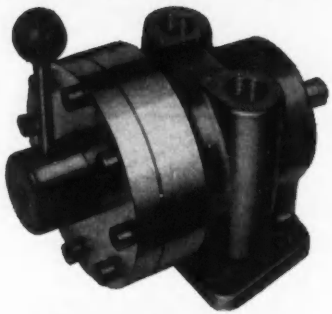
Pyro

A GREAT NAME IN CUSTOM INJECTION MOLDING

Serving Industry with the best engineering and production facilities for top quality Plastic Parts and Products.

PYRO PLASTICS CORPORATION
UNION NEW JERSEY

The Controlled Flow



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PROVIDES COMPLETE CONTROL OF VOLUME • • • DIRECTION • • • PRESSURE AT THE PUMP without Valves

These are only some of the features that the HYDROPUMP offers. For complete information, write for Bulletin 100-P.

MILWAUKEE HYDROPOWER, INC.
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Your Deep Drawn Stampings may require presses ranging from 30 ton to 1100 ton. We have them all. Outstanding plant facilities, coupled with the wide range of press sizes and competent engineers, make the Transue plant exceptionally well equipped for handling your stamping requirements.

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WHEN YOU NEED DEPENDABLE CONTROL VALVES

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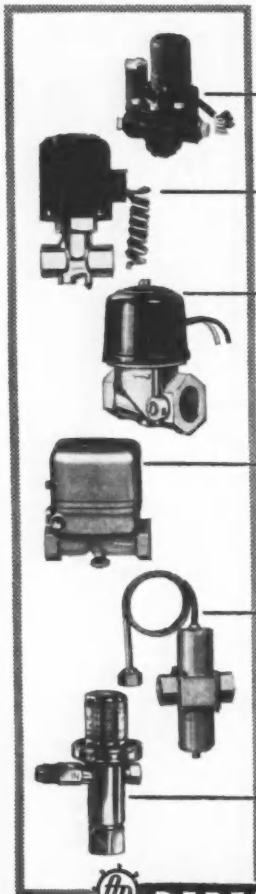
Control valves for air, gases, liquids or refrigerants must be completely dependable — particularly where automatic functioning of product or process is required. A-P offers years of experience, unexcelled engineering facilities, plus precision manufacturing methods and meticulous quality control to back up its guarantee of DEPENDABILITY in Service. A recognized leader in the field of flow-control, A-P offers a wide range of types and sizes — pressure, temperature or electrically controlled.



REMOTE CONTROL
SOLENOID VALVES

Heavy-duty, pilot-operated, industrial-type solenoid valves for water. Non-overheating moisture-proof coil, easily removable strainer and valve seat. Capacity to 3000 gal. per hr.

Multi-purpose solenoid valve. Handles air, water, or non-corrosive liquids and gases. Capacity up to 600 gal. per hr.

Rugged, long-life solenoid valve for low pressure air or gas control. Positive opening and seal-off, even with voltage or pressure variations. No sticking or gumming. Quiet, no-hum operation due to unique design.

SILENT, POSITIVE-OPERATION
THERMO-ELECTRIC GAS VALVES

Where inexpensive, reliable automatic temperature control is required, this thermo-electric gas valve has many advantages. Its diaphragm-operated power element is absolutely silent in operation. Positive, tight seal-off; full opening, full closing on 30-second cycle. Large capacity; compact size; dependable functioning.

PRESSURE-REGULATED
WATER VALVES

A-P water valves will control water flow in response to pressure changes. Unique valve design permits trouble-free operation even in very dirty water. Operating pressure adjustable from 65 to 300 p.s.i. Maximum water pressure 150 p.s.i. 3/8", 1/2", and 3/4" sizes; capacities from 3 to 42 gal. per min.

PRESSURE OR TEMPERATURE CONTROLLED
EXPANSION OR THROTTLING VALVES

Designed primarily for refrigerant control, A-P expansion valves are adaptable to many applications where automatic control of temperatures or pressures is required. If you have a problem involving the control of liquid or gas flow in response to pressure or temperature changes, a standard, low-cost A-P expansion valve may provide an immediate answer.

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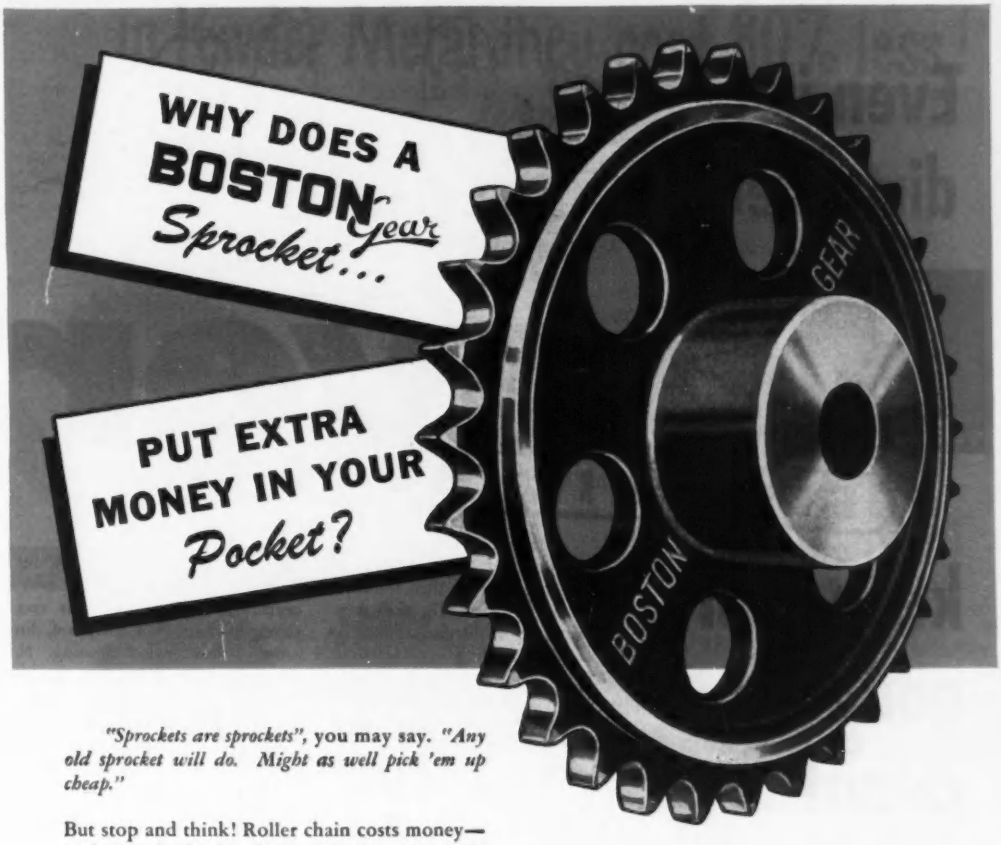
PUT EXTRA MONEY IN YOUR Pocket?



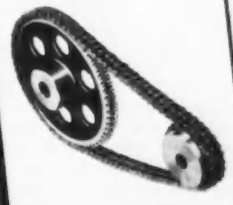
"Sprockets are sprockets", you may say. *"Any old sprocket will do. Might as well pick 'em up cheap."*

But stop and think! Roller chain costs money—is **increasingly hard to get.** Cheaply made sprockets with carelessly cut teeth chew up chain **fast** — reduce its life 20% or more. Sprockets that do not run true — that lack balance and correct tooth formation — waste power, too.

Chain — power — cost of shutdowns for replacement — check these against the small "saving" in first cost between a "bargain counter" sprocket and a sprocket of genuine BOSTON *Gear* quality design, materials, workmanship, finish and accuracy. **BOSTON Sprockets are cut with the same care and precision as BOSTON Gears.**

With Sprockets as with Gears, Reductors, Ratiomotors, Bearings and hundreds of other items of transmission equipment, it pays to standardize on BOSTON — readily available from nearby stock. (See adjacent list of Authorized Boston Gear Distributors).

Boston Gear Catalog No. 55 contains complete information and prices on over 4000 stock items. Write for free copy.



BOSTON *Gear* Sprockets and Chain cover a complete range of chain drive service from "flea" power to forty horse power.

Even in a dirty deal...

Hoover®

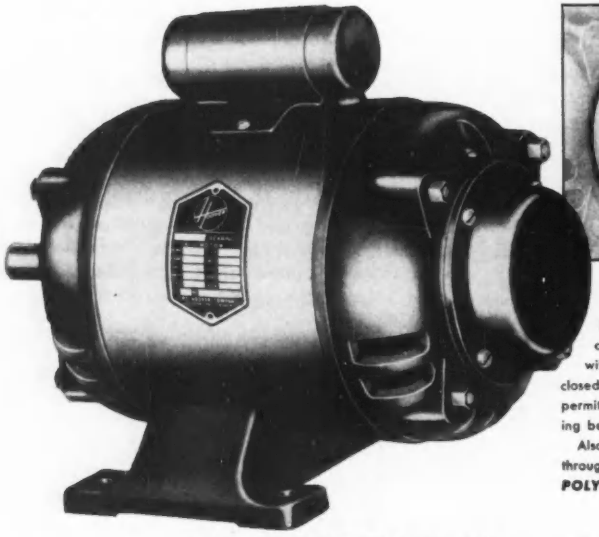
ELECTRIC MOTORS

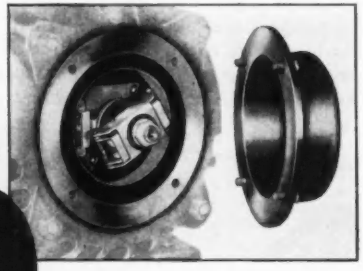
keep your good name clean!

When you make machine tools, your reputation depends on their smooth, dependable operation. Yet often they must work under dirty conditions—in dust, sawdust, filings or oil splashes that may prevent a motor from even starting. That's why so many machine-tool manufacturers power their products with Hoover Motors!

Hoover integral horsepower capacitor-start motors can be relied on for long, dependable service . . . and they get going on cue no matter how dirty their surroundings. For Hoover's centrifugal starting switch is completely enclosed in a dustproof, dirtproof, external switch housing. No dirt can ever get in to cause trouble.

There are many other Hoover Motors for many other needs. All are built like motors costing far, far more. There's sure to be a Hoover Motor to help keep *YOUR* good name clean! Write today for details.





Typical SINGLE-PHASE CAPACITOR-START HOOVER MOTOR. 1 HP, 1725 RPM. Dripproof construction. Features centrifugal starting switch with oversize electric contacts of pure silver, enclosed in an external, removable switch housing that permits easy access yet keeps foreign matter from lodging between contact points and causing trouble.

Also available: Other ***CAPACITOR-START*** models, ¼ through 3 HP. ***SPLIT-PHASE*** models, ¼ and ½ HP. ***POLYPHASE*** models, ¼ through 5 HP.

THE HOOVER COMPANY • Kingston-Conley Division
68 Brook Avenue, North Plainfield, New Jersey

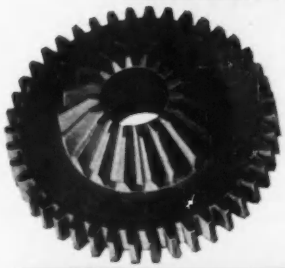
In Powder Metal they cost 80% less!

Products of Powdered Metal Products Corporation of America, Franklin Park, Illinois, specialists in gear making.

Bevel gear for power drill

Each of these gears is prohibitively expensive to make by conventional machining operations. In powder metal, each is formed at a single stroke.

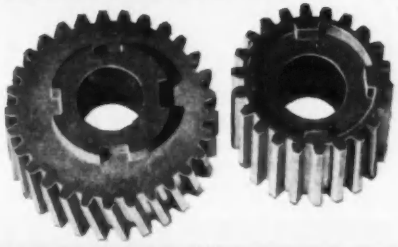
The small bevel gear for a power drill has a tensile strength of 100,000 psi. Savings in powder metal: 8 machine operations, 86% of total cost.



The mitre gear is used in a business machine. Savings in powder metal: 15 machining and assembly operations, 80% of total cost.

Spur and mitre gear for business machine

The helical and spur gear are used in an automatic washing machine transmission. Savings in powder metal: 18 machining and assembly operations, 88% of total cost.



Helical and spur gears for transmission in washing machine

To these and many other parts difficult or costly to form, powder metal processing is rapidly extending its many economies. Consult Stokes, makers of powder metal presses, on powder metal possibilities. Send parts or blueprints for report by Stokes engineers on their adaptability to powder metal processing.

A comprehensive booklet "Powder Metallurgy Today" will be sent on request.

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"BURR-PROOF"

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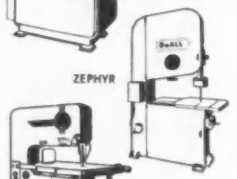
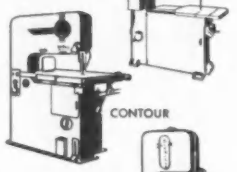
IS THE NEW EXCLUSIVE FEATURE OF

DoALL GAGE BLOCKS

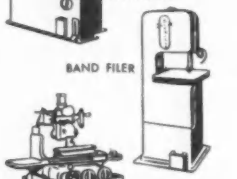
CONTOUR-MATIC



ZEPHYR



CONTOUR

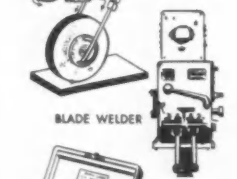


BAND FILER

TOOLROOM GRINDER

CRUSH GRINDER

"COOL GRINDING" ATTACHMENT



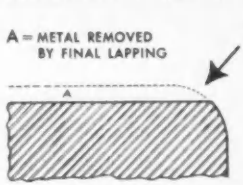
BLADE WELDER

GAGE BLOCKS

GAGE ACCESSORIES

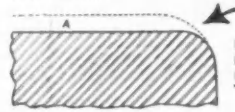
VARIABLE SPEED DRIVES

SAW BANDS



CONVENTIONAL GAGE BLOCKS

Ordinary usage raises burr or "wire edge" at sharp microscopic edges of standard gage blocks—which makes them unusable.



DoALL "BURR-PROOF" GAGE BLOCKS

The Secret of "Re-Rounded" Edges

Now, without added cost, you can have the new DoALL "BURR-PROOF" gage blocks that last twice as long as other standard blocks. Think of the great savings in replacement costs, fewer rejects and better quality products! Developed and used exclusively by DoALL, burr-proofing is the latest major achievement in gage block history. It "re-rounds" the edges of the blocks to prevent formation of microscopic burrs caused by ordinary usage. Burred edges are a major reason for discarding gage blocks—even a burr only 2 millionth inch can make a block unsuitable.

Although gage makers round the edges of the blocks to prevent burrs, the purpose of rounding is defeated by final lapping, which produces unwanted sharp edges. These become burred by the slight shocks and jars of normal handling. Mechanical operations to re-round the edges after lapping are avoided as they invariably cause distortion. Therefore the sharp edges left have been tolerated as a necessary evil—until the new DoALL process that "re-rounds" edges *without* distortion.

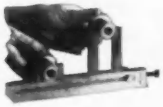
Part of DoALL's Integrated Inspection System

All DoALL gage blocks are burr-proofed. They are the key units of the integrated inspection equipment that DoALL manufactures for industry.

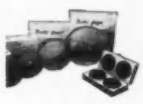
DoALL Makes the World's Finest Gage Blocks

The DoALL Store near you has a Gage Specialist at your service. Write for proof of DoALL Gage Block superiority today.

100% LONGER LIFE!



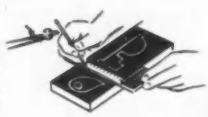
Gage Block Holders



Optical Flats

Comparators

Dial Indicators



TOOL STEEL

BENCH FILER

The DoALL Company

Des Plaines, Ill., U.S.A.

Cable Address: DoALL, Des Plaines

DoAll Stores In Key Cities

Factory Trained Representatives Everywhere

LaPLANT-CHOATE HYDRAULIC UNITS

Available Now For Your Heavy Duty Equipment

Proved by More Than 25 Years' Service on LPC Earth-moving Equipment

HYDRAULIC POWER CONTROL UNITS — Pump, Control Valve, Relief Valve and Reservoir contained in *one compact unit* permit desirable utility of space . . . result in exceptionally high efficiency rating, as oil flow restrictions are reduced to minimum, and complicated hose and pipes eliminated. Positively self-lubricated, operates under a wide range of climatic conditions. Easily installed in a wide variety of construction, mining and materials handling equipment, steering devices, etc.

HYDRAULIC PUMPS AND MOTORS — *Maximum over-all mechanical efficiency at normal working pressures!* That's operation with high efficiency and economy, producing smooth, vibrationless power flow. Correct design, unique engineering features, highest quality materials assure long, trouble-free performance in a wide range of automotive, portable or stationary applications. Other advantages . . . compact design, easy installation, elimination of complicated mechanisms, easy servicing, low maintenance. Fluid motors of constant displacement gear type, and reversible motors have the same design features as the pumps. Can be mounted in any position, and stalled under load without damage.

HYDRAULIC CONTROL VALVES — Assemblies consist of one or more valves, machined to a precision finish. Parts are interchangeable. Valves with exclusive LPC design for automatic oil surge control are optional.

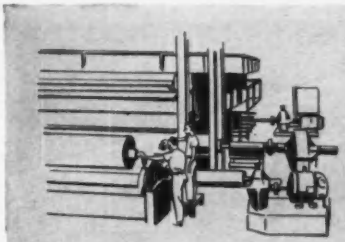
HYDRAULIC CYLINDERS — LaPlant-Choate is equipped to make Hydraulic Cylinders of ANY design, to meet any specifications. Furnish pertinent data . . . stroke, diameter and capacity . . . and we will gladly submit design to suit your requirements.

For the many advantages you'll want to know about—and use, *send for Bulletin A-1152B.*

LaPLANT-CHOATE MANUFACTURING CO., INC.
CEDAR RAPIDS, IOWA

LaPLANT-CHOATE

ROUND AND SHAPED TUBING
(.010" to ½" O.D. Max.
Certain Analyses .035"
max. wall to 1⅜" O.D.)
Available in
Carbon Steels:
A.I.S.I.—C-1008, MT-1010, MT-1015, C-1118, MT-1020, C-1025, C-1035, E-1095
Alloy Steels:
A.I.S.I.—4130, 4132, 4140, 4150, 8630, E-52100
Stainless Steels:
A.I.S.I.—303, 304, 305, 309, 310, 316, 317, 321, 347, 403, 410, 420, 430, 446, T-5
Nickel Alloys:
Nickel, "D Nickel"*, "L Nickel"*, "Monel"*, "K Monel"*, "Inconel"*, 30% Cupro Nickel, 18% Nickel Silver.
Beryllium Copper.
*Reg. U. S. Trademark International Nickel Company
The HOLE Story —by— Superior
Chapter 1
Shaping a Heart for a Pressure Gauge Requires "Technology in Tubing"
Soon after the tube pictured above comes off the shaping roll, it will be processed into a Bourdon tube, the heart of a pressure gauge, by one of our customers.
The design of a gauge movement and the skill of the gauge builder have a bearing on its accuracy. But nothing can compensate for an irregularly responding Bourdon tube.
That's where Superior comes in. The metallurgy of the tube, its dimensional precision and physical characteristics are all critical . . . and all are rigidly controlled at Superior.
This rigid control is applied to all tubing produced by Superior.
For example, in the production of seamless steel tubing for hydraulic applications, industry standards permit a carbon range of .08 to .18%. This range is not good enough for Superior. Aiming for a carbon content of .12%, Superior Hydraulic Quality tubing is always held to .15% maximum. This insistence on adherence to strict standards applies equally to dimensional tolerances.
Superior produces tubing to rigid specifications year in and year out. We have the engineers, metallurgists, research, production and test facilities that it takes to draw the highest quality small tubing in the widest variety of analyses.
You can call this combination of facilities, men, methods and machines "know-how" . . . or you can call it experience. But whatever you call it the result is always fine small tubing to do a better job for you.
SUPERIOR TUBE COMPANY, 2012 Germantown Avenue, Norristown, Pa.
West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. UNderhill 0-1331.
Superior
THE BIG NAME IN SMALL TUBING
All analyses .010" to ⅛" O.D.
Certain analyses (.035" max. wall)
Up to 1⅜" O.D.



RELIANCE V★S DRIVE®

...the Electrical Transmission

which gives you

STARTING without clutches!

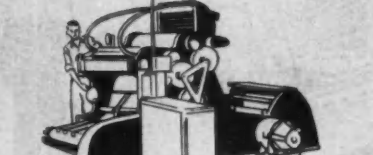
STOPPING without mechanical brakes or clutches!

REVERSING without use of gears or clutches!

ADJUSTABLE SPEEDS without mechanical transmissions or change of gears!

JOGGING, INCHING, CREEPING without slipping clutches!

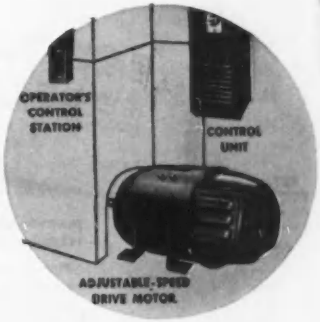
...from A-c. Circuits



Call your nearest Reliance Application Engineer or write today for Bulletin 311 (V★S Drives through 200 horsepower).

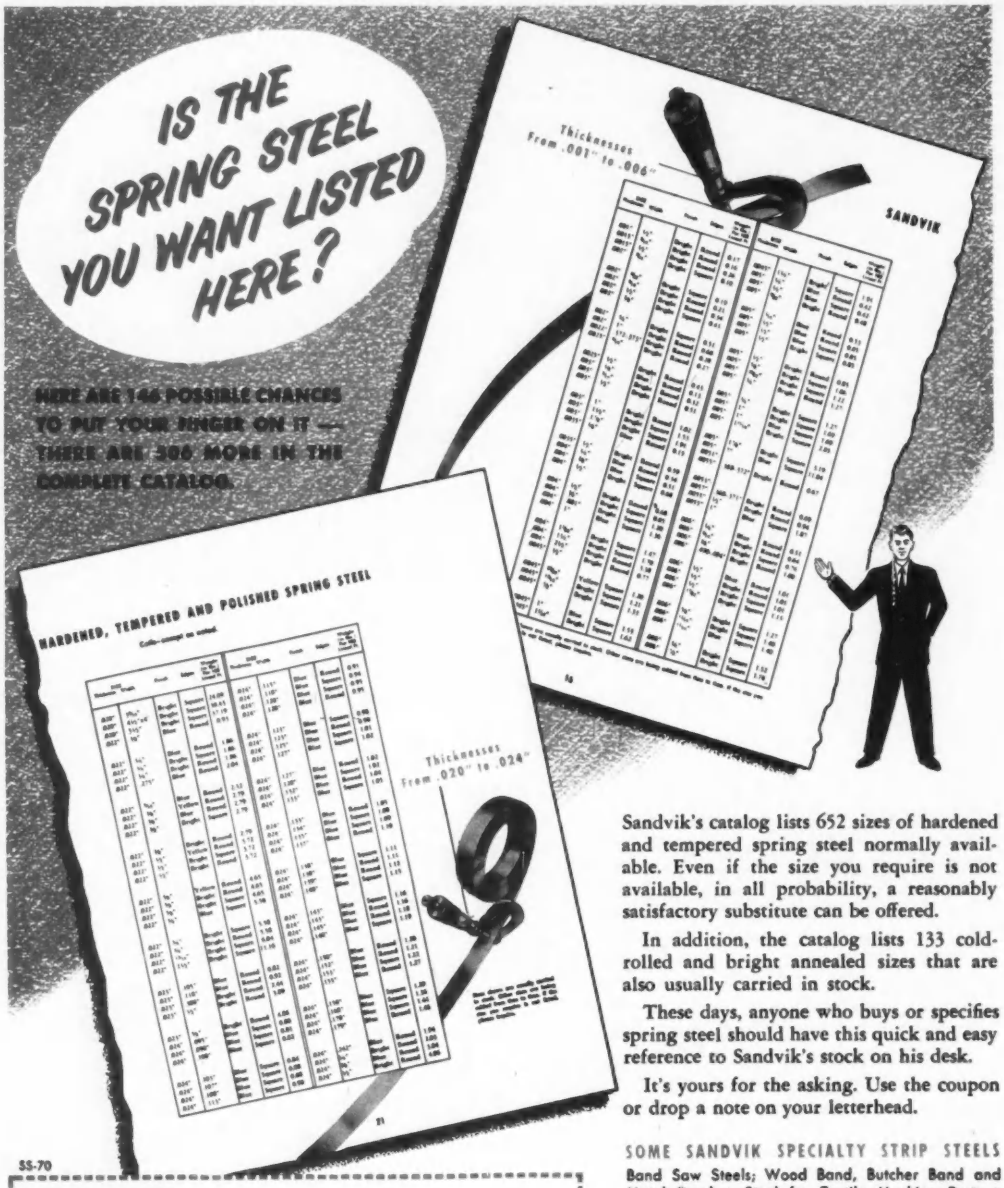
...write also for Bulletin D-2101 describing the

Smaller Reliance V★S Drive, in sizes from 3/4 to 3 horsepower. Performs all the functions of mechanical transmissions—electrically!



RELIANCE ELECTRIC AND ENGINEERING CO.

1080 Ivanhoe Road, Cleveland 10, Ohio • *Sales Representatives in Principal Cities*


IS THE SPRING STEEL YOU WANT LISTED HERE?
HERE ARE 146 POSSIBLE CHANCES TO PUT YOUR FINGER ON IT — THERE ARE 506 MORE IN THE COMPLETE CATALOG.
Thicknesses From .001" to .006"
SANDVIK
HARDENED, TEMPERED AND POLISHED SPRING STEEL
Thicknesses From .020" to .024"

Sandvik's catalog lists 652 sizes of hardened and tempered spring steel normally available. Even if the size you require is not available, in all probability, a reasonably satisfactory substitute can be offered.

In addition, the catalog lists 133 cold-rolled and bright annealed sizes that are also usually carried in stock.

These days, anyone who buys or specifies spring steel should have this quick and easy reference to Sandvik's stock on his desk.

It's yours for the asking. Use the coupon or drop a note on your letterhead.

SS-70

SANDVIK STEEL, INC.
111 Eighth Ave., New York 11, N. Y.

Please send me my free copy of your Spring Steel Catalog.

Name_____ Title_____

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SOME SANDVIK SPECIALTY STRIP STEELS

Band Saw Steels; Wood Band, Butcher Band and Metal Band • Steel for Textile Machine Parts • Camera Shutter Steel • Clock and Watch Spring Steels • Compressor Valve Steel • Doctor Blade Steel • Feeler Gauge Steel • Razor Blade Steel • Reed Steels • Shock Absorber Steel • Sinker Steel • Spring Steels • Trowel Steel • Vibrator Reed Steel, etc.

Sandvik Quality Steels

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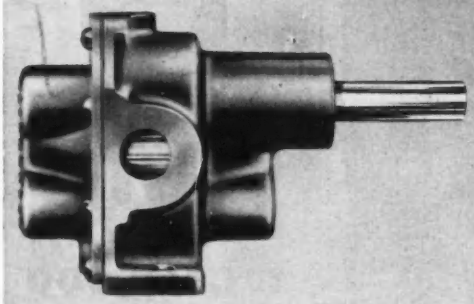
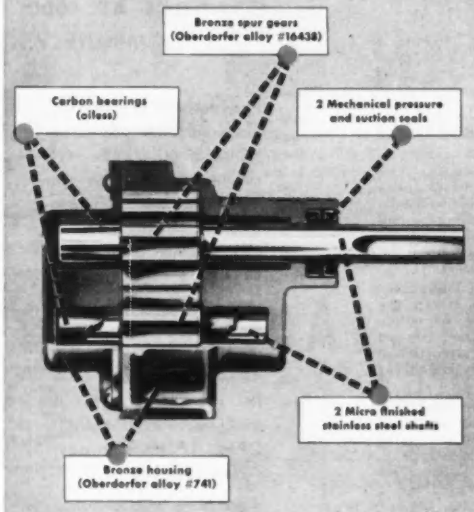
1736 Columbus Rd., Cleveland 13, CH 1-2303
SANDVIK CANADIAN LTD.
426 McGill St., Mont., Can.

Since the six OBERDORFER INTERNATIONAL pumps described below are new, with no prior history of use, Washington expects a DEFENSE ORDER or equivalent for their purchase. Free samples are available to O.E.M. accounts.

5 Major Points of Superiority in the New Series 1* ...

OBERDORFER INTERNATIONAL BRONZE ROTARY GEAR PUMPS




Bronze spur gears (Oberdorfer alloy #16438)
Carbon bearings (oilless)
2 Mechanical pressure and suction seals
2 Micro finished stainless steel shafts
Bronze housing (Oberdorfer alloy #741)

These precision built pumps have been specifically designed for long and economical industrial service, and to reduce liquid transfer costs in the vast variety of applications where they are suitable. Their five major points of superiority incorporate all the engineering and production knowledge amassed in building literally millions of bronze pumps over a period of more than 50 years. These new Series 1 OBERDORFER INTERNATIONAL pumps will prove their worth in intensive, on-the-job tests against any competitive pumps on the market today.

CAPACITY TABLES

Gallons of Water Per Hour for Series 1 OBERDORFER INTERNATIONAL PUMPS Outlet Pressure—P.S.I. (Pounds per square inch)

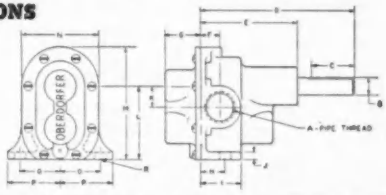
1725 RPM (Standard Electric Motor Speed)						
Pump Size	2 lbs.	20 lbs.	40 lbs.	60 lbs.	80 lbs.	100 lbs.
No. 1½	126	115	105	98	93	90
No. 2	245	225	215	205	195	190
No. 3	445	425	405	390	380	370
No. 4	640	610	580	550	530	510
No. 7	1185	1160	1140	1120	1100	1085
No. 9	1400	1375	1350	1325	1300	1280

PRICE LIST

Oberdorfer International Series 1
IMPORTANT: Order by Part Number

1½	2	3	4	7	9
Part No. 1000	Part No. 2000	Part No. 3000	Part No. 4000	Part No. 7000	Part No. 9000
$14.25	$15.75	$20.00	$22.25	$28.50	29.75

DIMENSIONS



PUMP No.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R
1½	½	½	1	3¹¹⁄₁₆	2¹⁄₁₆	¾	1⅛	⅛	1¼	⅜	⁵⁄₁₆	1⅛	2¼	1¾	⅞	1¼	⅜
2	⅝	½	1	3¹¹⁄₁₆	2¹⁄₁₆	⁵⁄₁₆	1⅛	½	1¾	½	⁵⁄₁₆	2¹³⁄₁₆	3⅜	2⅛	1⅛	1¾	⅜
3	½	⅝	1¼	4¹⁄₁₆	3	⁵⁄₁₆	1½	⅝	1¾	½	⅝	2⅝	4	2⅛	1⅜	1⅛	⅝
4	½	⅝	1½	5¹⁄₁₆	3¹⁄₁₆	⅜	1½	⅞	1¾	½	⅝	2⅝	4	2⅛	1⅜	1⅛	⅝
7	⅝	⅝	1½	5¹⁄₁₆	3¹⁄₁₆	½	1½	⅞	1⅝	⅝	1	3⅜	5½	3¼	1⅝	2⅛	⅝
9	1	⅝	1½	5¹⁄₁₆	3¹⁄₁₆	⅞	1½	⅞	1¹³⁄₁₆	⅝	1	3⅜	5½	3¼	1⅝	2⅛	⅝

FACTS ABOUT OBERDORFER

1. The third largest non-ferrous foundry in the U. S.
2. Over a half century of bronze pump manufacturing experience
3. Long-established world-wide pump distribution
4. Millions of pumps in service
5. Capitalization over one million dollars
6. 1951 capacity for 250,000 Series 1 OBERDORFER INTERNATIONAL pumps

* First of five new series

Write Dept. PE 514

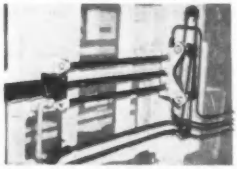
INDUSTRIAL PUMP DIVISION
Oberdorfer Foundries, Inc.
Syracuse, N. Y.

CHIKSAN

Hydraulic Swivel Joints help to simplify design

Hydraulic line fully extended, with turning movement taking place with CHIKSAN Swivel Joints.

As the Unpacker Head travels back and forth, the hydraulic line folds and unfolds automatically.



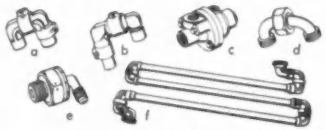
At the end of the stroke, the hydraulic line requires sharp bends which are possible only by using CHIKSAN Swivel Joints.

With CHIKSAN Hydraulic Swivel Joints you can design and build flexible hydraulic lines to handle pressures to 3,000 psi . . . and thereby gain advantages not obtainable by any other method. A typical example is the *Ermold Automatic Case Unpacker.*

CHIKSAN Hydraulic Swivel Joints make possible sharp bends, thus permitting installations where space is limited. They eliminate drag and snag. In addition, you get uniform low operating torque, strength and safety under all conditions. All-metal tubing assures longer life.

There are 5 Basic Types of CHIKSAN Swivel Joints — a Type for every purpose. CHIKSAN Engineers will gladly cooperate with you in selecting the correct Type . . . either standard or of special design . . . for your specific requirements.

(a) Basic Type Swivel Joints — for pressures from 125 psi. to 15,000 psi. (b) High Temperature Swivel Joints for temperatures to 500° F., working pressures to 700 psi. (c) Rotating Joints for 150-lb. steam, brine, etc. For hot and cold rolls, tumblers, platens, etc. (d) Sanitary Swivel Joints for food processing, fruit juices, dairies, etc. (e) Hydraulic Swivel Joints for pressures to 3,000 psi. For aircraft, industrial and armored equipment. (f) Flexible Lines, designed and fabricated to meet specific requirements.



WRITE FOR CATALOG NO. 50-AH

Representatives in Principal Cities

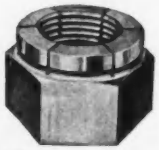
CHIKSAN TRADE MARK REG.

CHIKSAN COMPANY AND SUBSIDIARY COMPANIES
NEWARK 2, N. J. **BREA, CALIFORNIA** CHICAGO 3, ILL.
CHIKSAN EXPORT COMPANY, 155 WASHINGTON ST., NEWARK, N. J.
WELL EQUIPMENT MFG. CORP., HOUSTON 1, TEXAS

BALL-BEARING SWIVEL JOINTS FOR ALL PURPOSES

FLEXLOC

SELF-LOCKING NUTS



STAY TIGHT AFTER 171,360,000 VIBRATIONS AT 4000 CYCLES PER MINUTE . . .

Plain nuts with lock washers loosened after only ONE HOUR of 4000-cycle-per-minute operation on the vibrator of a concrete block machine at the plant of the Bethayres Concrete Block Co., Bethayres, Pa.

When FLEXLOC Self-Locking Nuts were installed, they were *still tight* when the machine was torn down for rebuilding after 6 weeks operation — at 4000 C.P.M., 17 hours a day, 7 days a week!

If you have an application where nuts loosen or back off, try FLEXLOC, the one-piece, all-metal STOP- and LOCK-NUT "that won't work loose."

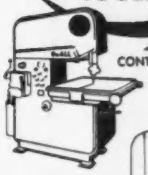
Send for Bulletin 619-A today.

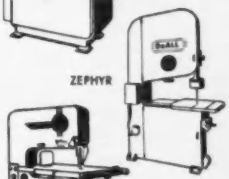
—SPS—

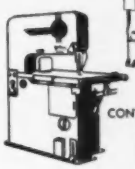
STANDARD PRESSED STEEL CO.
JENKINTOWN 28, PENNSYLVANIA

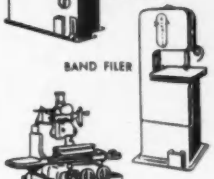
DoALL

INDUSTRY'S NEW SET OF TOOLS


CONTOUR-MATIC


ZEPHYR

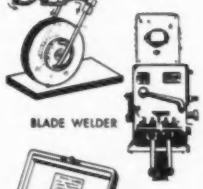

CONTOUR


BAND FILER

TOOLROOM GRINDER

CRUSH GRINDER

"COOL GRINDING" ATTACHMENT


BLADE WELDER

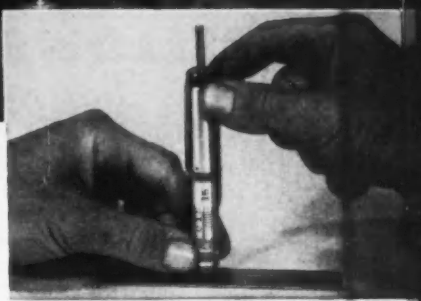
GAGE BLOCKS

GAGE ACCESSORIES

VARIABLE SPEED DRIVES

SAW BANDS

G. N. Krouse, owner of Krouse Testing Machine Co., Columbus, Ohio, inspecting 5" micrometer scales after "Cool Grinding" on DoALL Model G-1 Surface Grinder. These scales with .001" taper from end to end are held to accuracy of .00002" (20 millionths of an inch). Their micrometers and scales are used to measure plating thickness.



DoALL COOL GRINDING

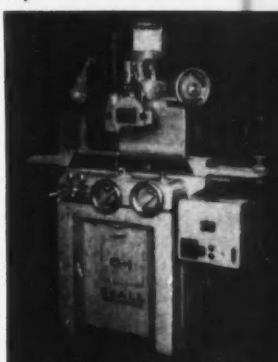
U.S. Patent No. 2470350

(Coolant-through-the-Wheel)

This patented technique used with a DoALL Surface Grinder opens an entirely new grinding era—faster, more accurate, better finishes.

1. Cooler grinding temperature.
2. Full visibility of work. No mess.
3. Longer wheel life—less "loading," less frequent dressing.
4. Finer finish—no cracking, warping or "skin softness".
5. No special wheels required, no power consuming pumps, no space taking tanks.

SEE HOW IT WORKS. Interesting because it's so revolutionary. Call your local DoALL Store today and ask for a demonstration.


"Cool Grinding" on the DoALL Super Precision Grinder (7 models available)

TOOL STEEL

BENCH FILER

The DoALL Company

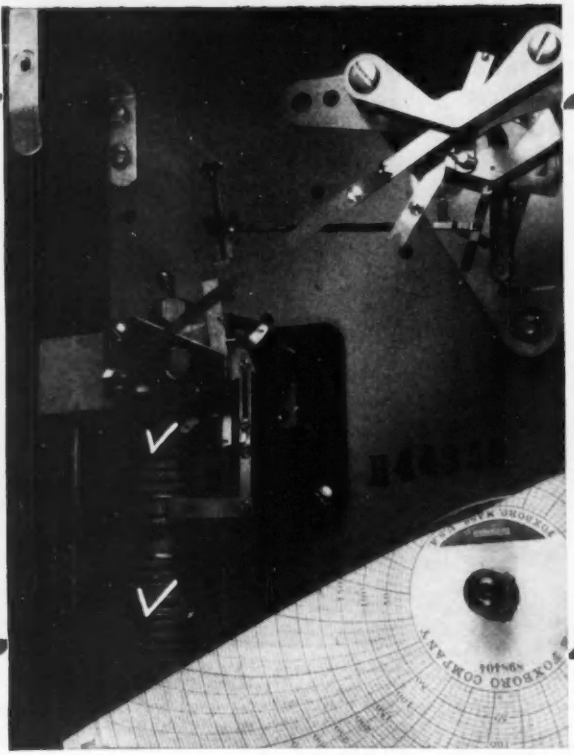
Des Plaines, Ill., U.S.A.

Cable Address: DoALL, Des Plaines

DoAll Stores in Key Cities

Factory Trained Representatives Everywhere

Build better performance into your product *with* FLEXON BELLOWS



PRODUCT performance is dependent largely upon the performance of component parts . . . first rate performance requires first rate components. If metallic bellows are a part of your product you owe it to yourself to investigate FLEXON Bellows.

For the designer, FLEXON Bellows offer a combination that assures top notch performance and rigid adherence to specifications:

(1) Advanced manufacturing techniques permit fabrication of a wide variety of bellows and bellows assemblies as standard production items. This provides a higher degree of uniformity and resultant lower ultimate cost to you.

(2) Skilled manufacturing personnel with long experience have an appreciation of your problems and the importance of exact compliance with your specifications.

FLEXON Bellows are available in stainless steel, brass, bronze and other alloys with sizes ranging upward from 5/16" I.D. Whatever your requirements in bellows or bellows devices, check with CMH first. Experienced CMH engineering assistance is available to help you in the design or selection of the proper bellows to meet your needs.

Write for a copy of the new Flexon Bellows catalog. For specific recommendations send details of your application.

Illustrated above is a close-up of the mechanism of an absolute pressure recorder manufactured by the Foxboro Company in which FLEXON stainless steel bellows are used.

Flexon identifies CMH products that have served industry for over 49 years.

CHICAGO METAL HOSE Corporation

1351 S. Third Ave. • Maywood, Ill. • Plants at Maywood, Elgin, Rock Falls, and Savanna, Ill.
In Canada: Canadian Metal Hose Co., Ltd., Brampton, Ont.

CMH

ONE DEPENDABLE SOURCE
for every flexible metal hose requirement

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Boeing Aerial Tanker delivers fuel twice as fast with weight saving of 550 lb.

•

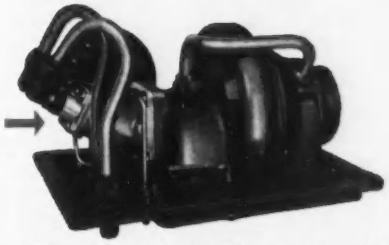
Uses New Refueling Pump driven by VICKERS HYDRAULIC MOTOR

Another Example of How VICKERS HYDRAULICS

1 IMPROVES PERFORMANCE — **2 SAVES WEIGHT AND SPACE**

A significant advancement in in-flight refueling has been made possible by a new hydraulically driven fuel transfer pump (shown at the right). On the Boeing KC-97A Stratofreighter aerial tanker, two of these replaced 16 electrically driven pumps and deliver almost twice as much fuel per minute. The weight reduction was 550 lb. with an important saving in space. Totally submerged in the fuel tank, this new pump eliminates trouble from vapor lock . . . serious at high altitudes.

Vickers Hydraulic drives are also used for the accurate control required in guiding the fuel transfer boom. These hydraulic drives, powered from the engines, greatly reduce the tanker's electrical power requirements. Vickers builds the most complete line of hydraulic equipment for aircraft. Ask for new Bulletin A-5200.



New refueling pump, designed under supervision of US Air Forces, Air Materiel Command and built by Nash Engineering Co. Arrow points to Vickers Hydraulic Motor (Piston Type—Constant Displacement) directly coupled to pump drive-shaft. Entire unit is completely submerged in fuel tank.

4483

VICKERS Incorporated · 1454 OAKMAN BLVD., DETROIT 32, MICH.
DIVISION OF THE SPERRY CORPORATION
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

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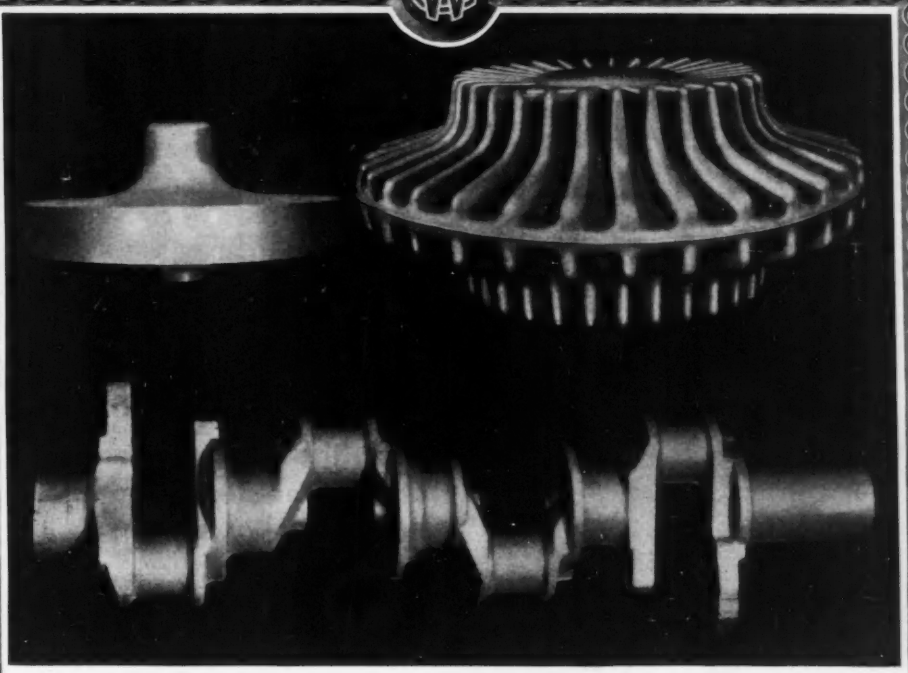

Wyman-Gordon—specialists in the vital forgings of the internal combustion engine since its inception--is today the largest producer of crankshafts for the automotive industry and of all types of forgings for the aircraft industry. Be it crankshafts and other vital forgings for the piston type engines or turbine wheels and impellers for turbo jets—there is no substitute for Wyman-Gordon experience.

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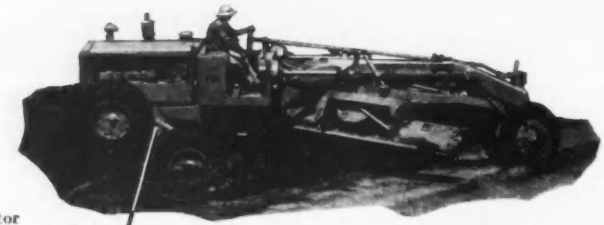
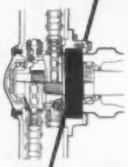


This rugged motor grader, made by Caterpillar Tractor Co., Peoria, Illinois, features a tandem-swing drive in its rear wheel design which gives it great traction and grade accommodation.



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stands up where metals fail!

Graphited plastic laminate eliminates sleeve trouble in "Caterpillar" Motor Grader

On their Motor Grader tandem-drive housing pivot bearings, Caterpillar Tractor Co. experienced premature sleeve bearing wear. These bearings are subjected to intermittent oscillating motion and are difficult to lubricate. Field reports showed that metal sleeves became scored after only 300 to 600 hours of operation.

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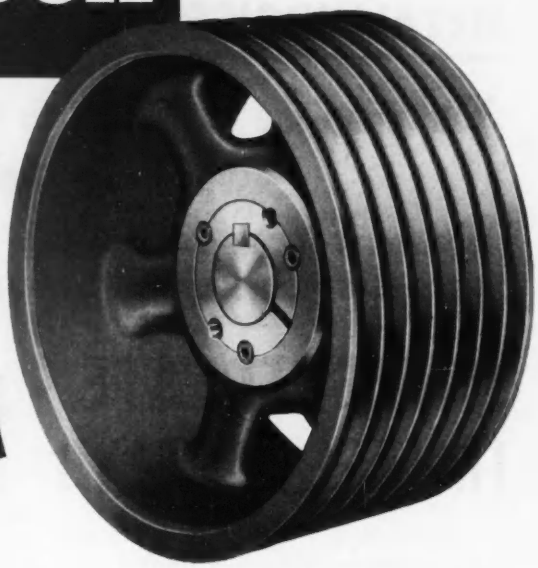
Easy on—Easy off



TAPER-LOCK bushing grips the shaft for the full length of the bushing — holds sheave with firmness of a shrunk-on fit. No wobble. Taper-Lock runs true!

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Finest grade of close-grained semi-steel, cast in the Dodge foundry.

The grooves, machined on precision equipment, have identical pitch diameters. This insures equal belt tension. Every belt pulls its share of the load!

TAPER-LOCK sheaves are available from distributors' stocks in complete range of sizes in A, B, C and D grooves.

DODGE SEALED-LIFE BELTS have special protection for tension members, insuring longer belt life. Perfectly matched to TAPER-LOCK sheaves.

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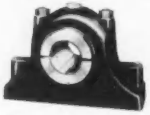

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DENISON HydrOILic Relief, Sequence and Unloading VALVES

Their Faster Action Gives Closer Control of Pressures

In Denison Pressure-Control Valves, *lower differential between opening and closing pressures* brings faster action . . . greater accuracy of pressure regulation . . . closer control of hydraulic system pressures.

Along with many other advanced features, this high efficiency is the result of a *quarter century* of engineering research and manufacturing experience at Denison. It is the product of engineers who have *specialized* in the design and construction of oil-hydraulic equipment, for every type of need.

Another feature of Denison's extensive line of hydraulic pressure control valves is the *extremely close fit* of all sealing surfaces within the valve bodies. This also leads to a higher level of operating efficiency, by reducing leakage to near-zero.

In addition to unusually compact construction that means extra ruggedness, saves space, and simplifies circuit design, Denison HydrOILic Valves are built for widest latitude in positioning and mounting the valves in the hydraulic system. They are available with threaded bodies, or for subplate mounting. The pressure-regulating control can be placed in either of two positions, for easiest access. Remote control of this regulation is also available.

Comparison is the quickest, easiest way to prove the many advantages of this group of Denison HydrOILic Valves, as hundreds of users in every field have already discovered. It will pay you to check with Denison for valves of *any type*, for circuit needs up to 5000 psi.

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For Circuit Pressures to 5000 psi

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- Less differential between opening and closing pressures.
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- Provision for gauge or pilot circuit connection.
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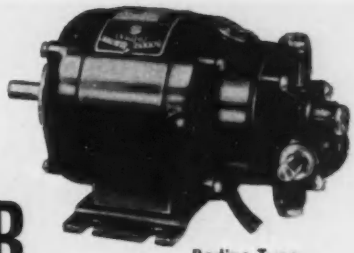
- Extremely close fit of all sealing surfaces cuts leakage to near-zero.
- Threaded-body or subplate mounting.

DENISON HydrOILics

New Label Dispenser uses a BODINE MOTOR

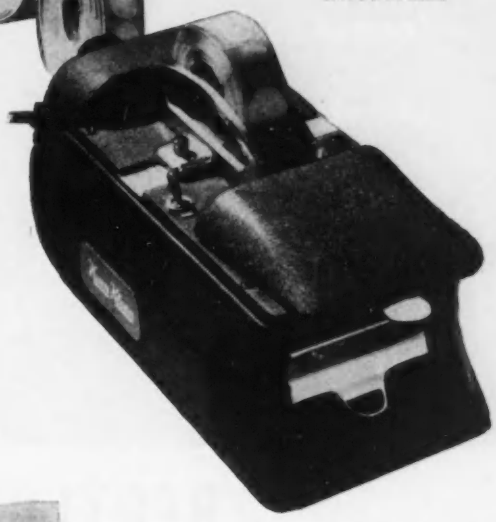


Bodine Type NSE-11R Speed Reducer Motor

The Avery Adhesive Label Corp. needed a motor that would provide stable operation over a wide speed range and varying loads...on a stop and go basis through rheostat control...for their new Kum-Kleen Label Dispenser. Labels were to be fed through the dispenser at a rate that varied from 6 to 150 lineal inches per minute. Even when operating at its lowest speed, the machine would be required to stop and start, yet accelerate quickly and accurately.

Working as a team, Bodine's local representative and factory engineers developed a special motor winding and control circuit that not only met all customer requirements, but was capable of start and stop operation, without stalling, at speeds as low as 1 to 2 lineal inches per minute.

Why not let Bodine know-how provide you with motors best suited to your particular application? Nearly half a century of experience insures satisfaction. It will pay you to consult Bodine engineers.



REASONS WHY

"Our new Kum-Kleen Label Dispenser is now using a Bodine Motor and we feel impelled to write you this complimentary note on two particular counts: 1—The first has to do with the obvious quality of Bodine motors over those used previously. The appearance, power, quietness of operation and standard performance characteristics of your motor have added measurably to our product. 2—The second is the truly astonishing performance characteristics which your local representative designed into these particular motors."

R. S. Avery, President
Avery Adhesive Label Corp.
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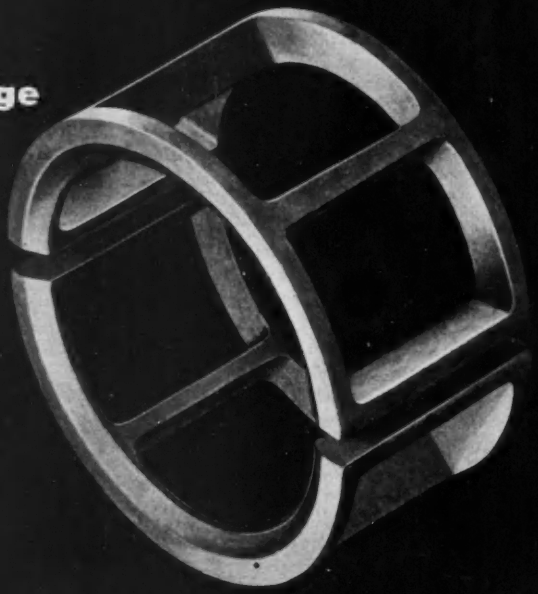

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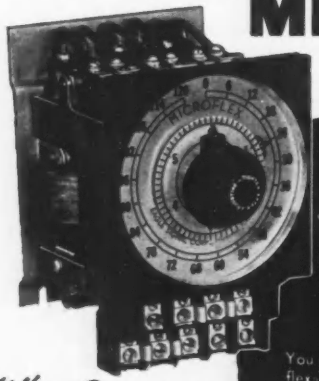

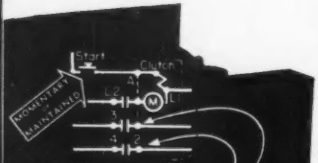

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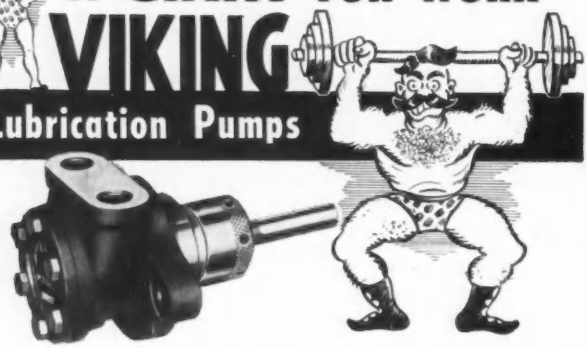

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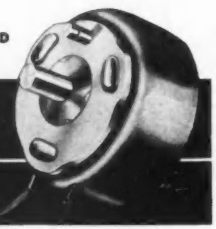

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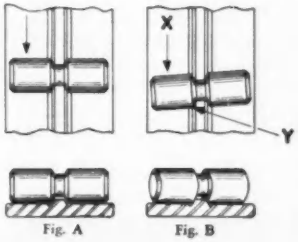

Fig. A Fig. B

A guide rail on the inside diameter of the outer race maintains roller alignment. Normally no correction is required. Should misalignment cause tendency to skew, the guide rail touches grooved rollers back into position by momentary contact at Y. X indicates direction of roller rotation.

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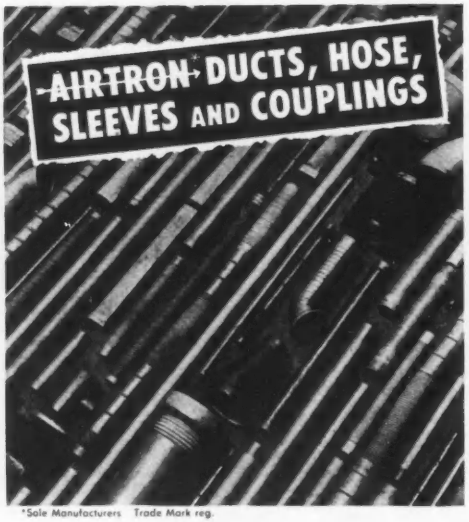

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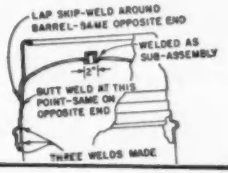
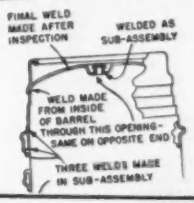
ORIGINAL DESIGN


LAP SKIP-WELD AROUND BARREL-SAME OPPOSITE END
WELDED AS SUB-ASSEMBLY
2"
BUTT WELD AT THIS POINT-SAME ON OPPOSITE END
THREE WELDS MADE

MODIFIED FOR PRODUCTION


FINAL WELD MADE AFTER INSPECTION
WELDED AS SUB-ASSEMBLY
WELD MADE FROM INSIDE OF BARREL THROUGH THIS OPENING-SAME ON OPPOSITE END
THREE WELDS MADE IN SUB-ASSEMBLY

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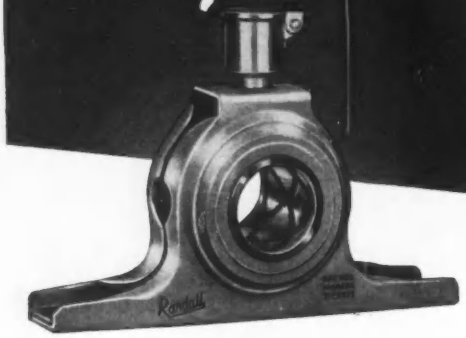

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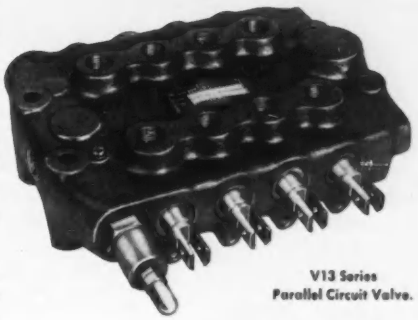

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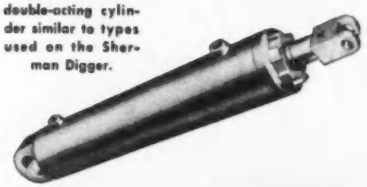
A typical HYDRECO double-acting cylinder similar to types used on the Sherman Digger.



All hydraulic cylinders on the Power Digger are HYDRECO built and designed for digging operations in all kinds of ground and materials and under all conditions. Efficient rod wipers and cylinder packings *keep oil in and dirt out* of the hydraulic system.

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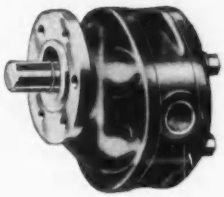

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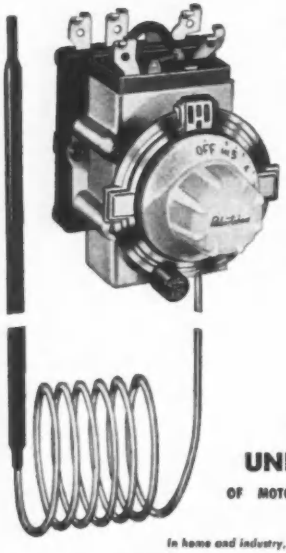

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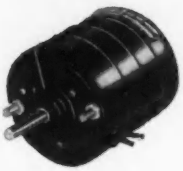

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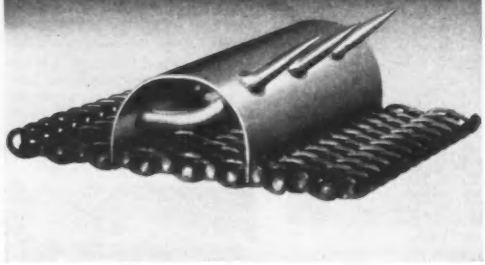
ever see a conveyor belt with horns?



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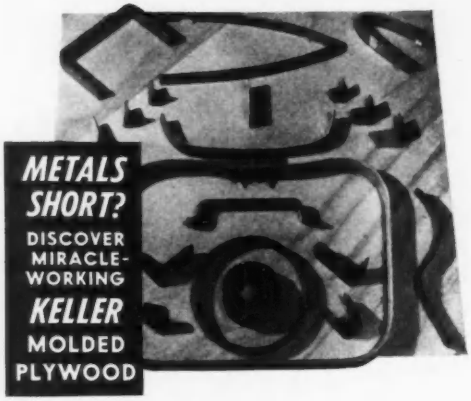

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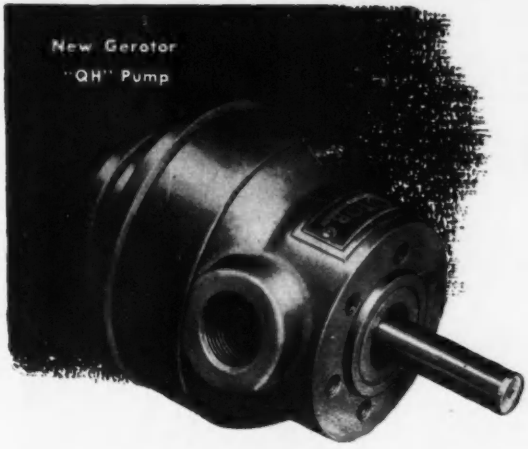

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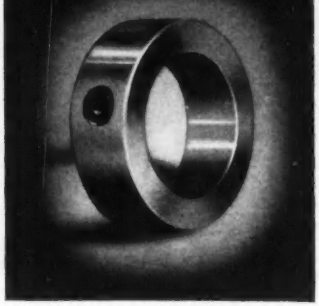

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—SPS—

STANDARD PRESSED STEEL CO.
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MEMO TO DESIGNERS who must:

Fight Heat

Jet Combustion, Inc., recently designed a new type of industrial furnace for heat-treating steel rod. Screw conveyors and troughs were required to move the rod through the furnace at 1650-1700° F. Our engineers worked with the customer on design of both troughs and conveyors—recommended Thermalloy* 50 Heat Resistant Alloy for the job. Results have proved most satisfactory.

Fight Corrosion

Corrosion resistance is a big factor in a food chopper, as in other food processing equipment. We worked closely with Toledo Scale Company on the design of the food chopper cylinder of their "Toledo Chopper"—recommended Chemalloy* (Ni-Resist Type 2) for the job. Result: continued quantity orders.

Do these two examples suggest that we can be helpful on product problems, where high alloy castings are required to fight heat or corrosion? We hope they do, for we have found that in similar cases, the potential volume has justified considerable design and metallurgical study and development. Write Electro-Alloys Division, 2121 Taylor Street, Elyria, Ohio.

*Reg. U. S. Trade Mark

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

This Special Pittsburgh Brush*

CLEANS RED-HOT CASTINGS in 30 seconds

* *An actual case history from the U. S. Pipe and Foundry Company, Birmingham, Alabama*

A PITTSBURGH brush provides the answer for U. S. Pipe and Foundry's problem of cleaning red-hot castings. This rugged brush works 40 hours a week, turning out thoroughly cleaned castings at the rate of one every 30 seconds . . . a speed record for any brush cleaning operation of this type.

LET PITTSBURGH ENGINEERS SOLVE YOUR BRUSH PROBLEMS

Pittsburgh's complete line of brushes of every type, for every purpose, will provide a practical, economical solution of any brush problem you might have. Drop us a line on your company letterhead for a copy of our new booklet that shows, through actual case histories, how Pittsburgh can help cut your brushing operation costs. Address: PITTSBURGH PLATE GLASS COMPANY, *Brush Div.*, Dept. W2, 3221 Frederick Ave., Baltimore 29, Md.

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PPG *Power Driven* **BRUSHES**

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PITTSBURGH PLATE GLASS COMPANY

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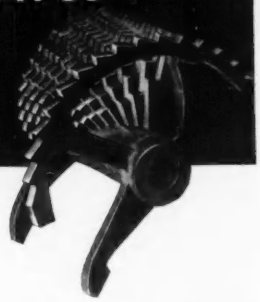


HERE is an outstanding example of what an Arwood precision investment casting can do.

This is a justifying cam used in a business machine and it was originally designed as a series of 18 stampings to be assembled by pinning and brazing. In its manufacture, Arwood was able to show a savings of 90% and at the same time triple the strength and wear-resistance of the cam. No hand filing or fitting is required in assembling the cast parts and all are completely interchangeable.

Perhaps you have a production problem that Arwood can help you solve. Our engineers, with years of experience in many industries, often are able to make valuable suggestions that result in important savings in manufacturing.

For more complete information about the accuracy, the lower costs and the versatility of precision casting, write for our booklet, "A Critical Survey of Investment Castings."

ARWOOD

PRECISION CASTING CORP.

68 WASHINGTON STREET • BROOKLYN 1, N. Y.

Plants: Brooklyn, N. Y., Groton, Conn., Tilton, N. H.

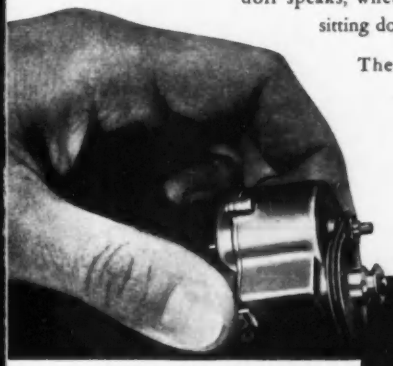
She SINGS . . . *She* LAUGHS

She TALKS . . . *She* PRAYS

. . . all because of the STROBOTAC®

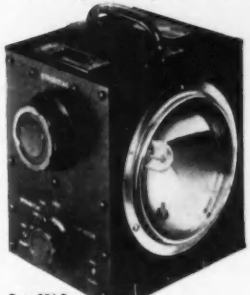
This Effanbee Doll, manufactured by a division of the Noma Electric Company, is the pride and joy of thousands of little (and big) girls. She is made vocal by means of a very cleverly designed, "built-in" talking machine, the heart of which is a miniature electric motor which operates on 2 standard flashlight batteries.

The batteries, motor, small phonograph turntable, minute record, pick-up and loudspeaker are housed in a plastic container inside the doll. A touch of a concealed button and the doll speaks, whether standing, lying or sitting down.



The small, precision-built motor has to be held to a speed between 4350 and 4550 rpm in manufacture. It is impossible to measure its speed with a mechanical tachometer. Blake Manufacturing Corporation of Clinton, Massachusetts, who make the motors, use four STROBOTACS in test jigs to check the speed of these motors as they move through production. Any motor which does not meet the speed limits is rejected.

Simple test jigs hold Blake motors while their speeds are checked in three motor positions by STROBOTACS mounted above them. A small plastic sleeve, marked with a black indicating line is slipped over the motor shaft to be "stopped" by Strobotac measuring motor speed within 1%.



Type 631-B
STROBOTAC®
Direct-Reading Speed Range: *600-14,400 per minute. Stops motion 100 to 100,000 rpm.*
Flash Duration: *between 5 and 10 millionths of a second.*
Power Source: *any 115 volt, 60 cycle line.*
Power Input: *25 watts.* **Size:** *7½ x 8¼ x 9.*
Weight: *9½ lbs.* **Price:** *$140.00*

To Blake, as to thousands of other manufacturers of electrical and mechanical equipment, the STROBOTAC has made possible entirely new manufacturing, designing and testing techniques. We'd like to suggest some of STROBOTAC'S possibilities to you.

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Blood Brothers are ready to supply universals and propeller shafts of the type and to the specifications best suited to your product needs. Long experience — plus complete facilities for producing and testing every type of universal joint — assure you the best of service and performance. Write for complete information.

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A Division of Standard Steel Spring Co.
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A NOVEL and UNIQUE CIRCUIT INDICATOR

DESIGNED FOR NE-51 NEON LAMP
For 110 or 220 volt circuits
The required resistor is an integral part of this assembly —"built-in."
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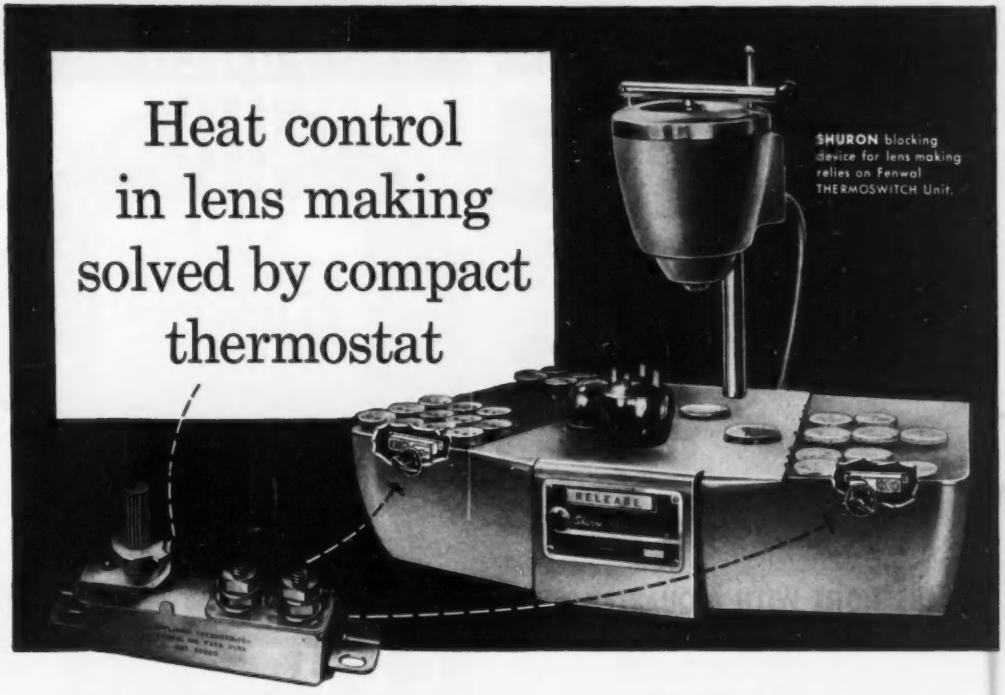
Heat control in lens making solved by compact thermostat



SHURON blocking device for lens making relies on Fenwal THERMOSWITCH Unit.

When the Shuron Optical Company designed a new machine for speeding up the lens-blocking operation, the problem of heat control proved a vital factor. Both lenses and blocks had to be warmed on hot plates at pre-determined temperatures that had to be uniform.

Shuron needed a very compact thermostat that could be depended upon for long-lasting, reliable, accurate performance. Cost was also important. After experimenting, the Fenwal Appliance THERMOSWITCH Unit was selected as best able to meet all requirements. It was approved as a standard specification on the Shuron device, successfully performs its function with regular efficiency.

The use of the Fenwal Appliance THERMOSWITCH Unit by the Shuron Optical Company is but one of many ways in which this unique, minimal size, low-cost thermostat is benefiting industry. Its activating control element is the single-metal stainless steel case that expands or contracts *instantaneously* with temperature changes, making or breaking the totally enclosed electrical contacts.

You, too, can benefit from Fenwal performance. Wherever heat is a factor, you can rely on THERMOSWITCH Units for effective control. For further details, mail coupon below.

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THERMOSWITCH®

The Precision, Multi-Purpose, Thermostat Control

SENSITIVE...*but only to heat*

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OTHER (Please fill in your special requirements) .....

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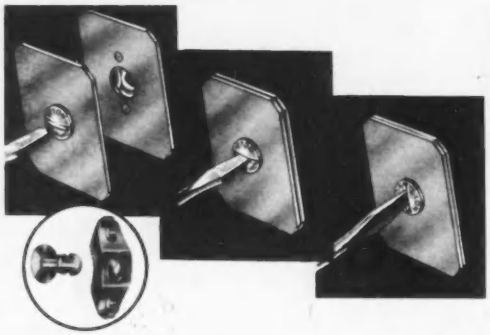
For Parts that must be

TAKEN OFF–PUT BACK–BUTTONED TIGHT

LION FASTENERS



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Vibration and shock can't loosen a Lion Fastener. Even an inexperienced service man can't replace it wrong. A quarter turn opens it. Another quarter turn locks it. The tension is *designed into it.*

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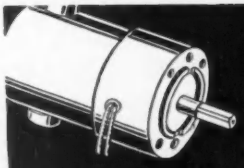

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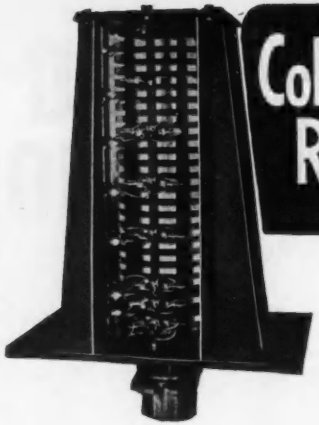

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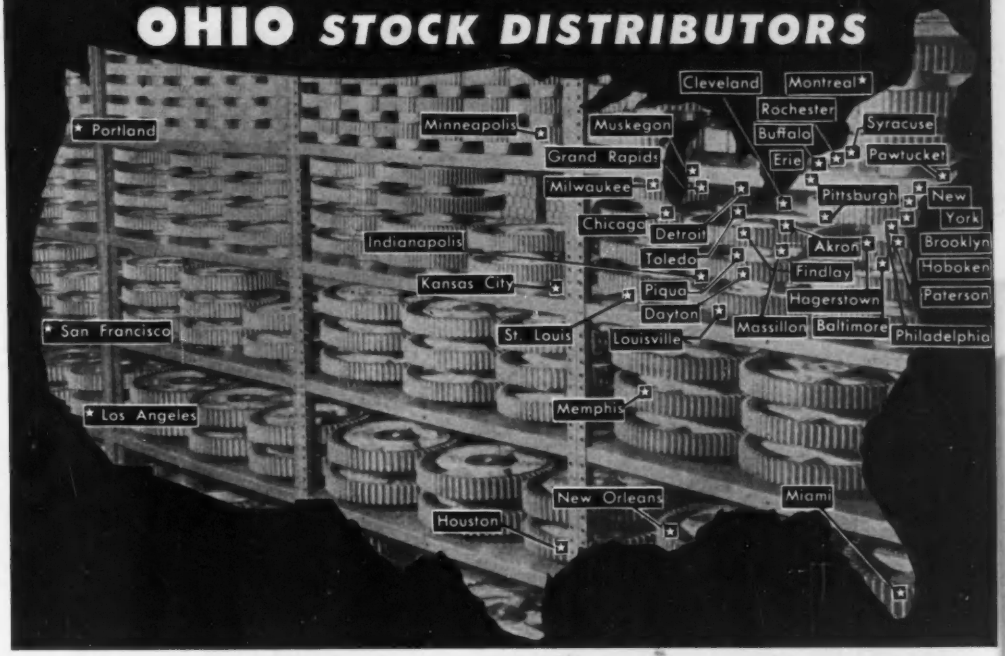

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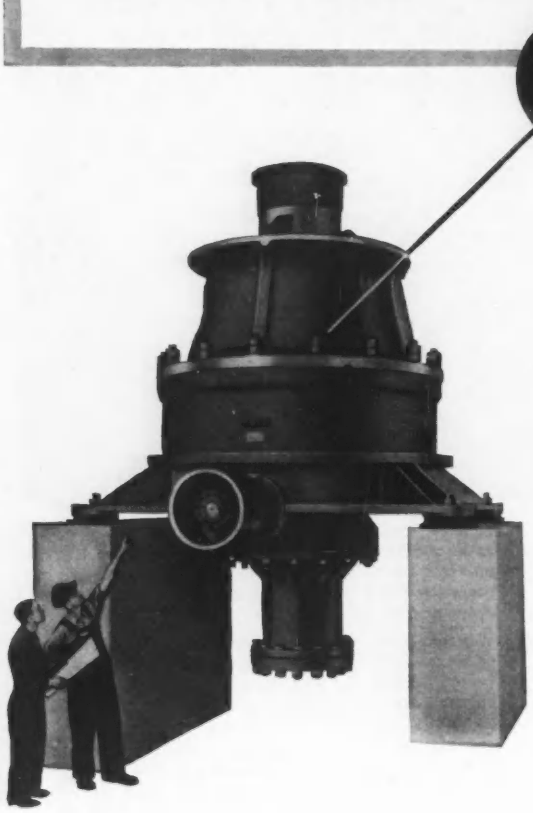

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Economy Way to Get Volume!
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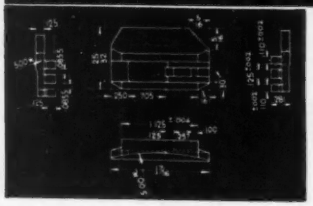
CAST TO MICROMETER TOLERANCES



Part:
SEWING MACHINE FEED DOG

Alloy: Miscrome 1 (A.I.S.I. Type 420 Nominal)
Weight: .06 oz.

Misco Precision Castings eliminate machining. This part was precision-cast to tolerances within a few thousandths of an inch on most dimensions.

We illustrate a Misco precision cast stainless steel sewing machine part weighing .06 ounces as cast. It replaces a part formerly machined out of solid stock, eliminating costly operations such as broaching, contour milling and hand grinding of irregular surfaces. Misco, a pioneer producer, has extensive technical experience and adequate facilities for large-quantity, low-cost processing of small alloy steel parts to exacting physical and metallurgical specifications.

The Misco Precision Casting Process offers you an economical way of producing hard-to-make parts in highly alloyed stainless as well as in carbon and low alloy steels. We will assist with the design, material and production details.

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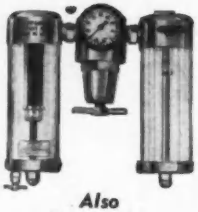

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SINGLE
REVOLUTION
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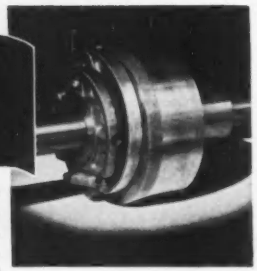

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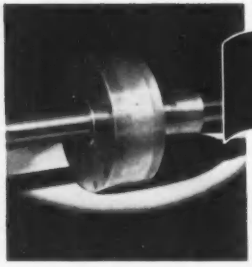

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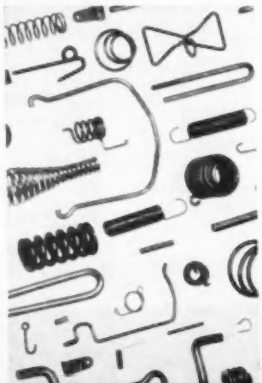

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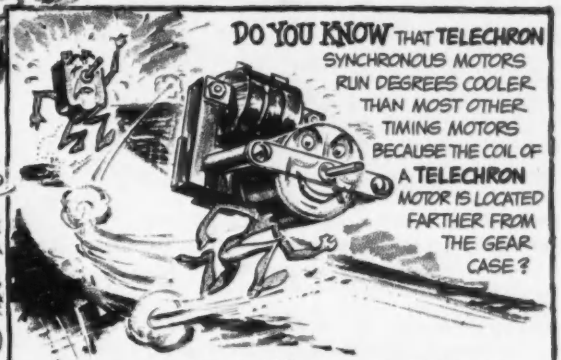
DO YOU KNOW THAT THE ROTOR SHAFTS OF MANY **TELECHRON** SYNCHRONOUS TIMING MOTORS HAVE MADE MORE THAN **30 BILLION** CONTINUOUS REVOLUTIONS AND THAT THE MOTORS ARE STILL OPERATING AS ACCURATELY AND DEPENDABLY AS WHEN THEY WERE NEW?



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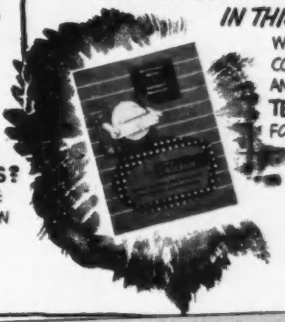
READ ALL ABOUT TELECHRON MOTORS IN THIS BULLETIN



WRITE FOR BULLETIN IS-110 WHICH CONTAINS CHARTS, TORQUE RATINGS AND COMPLETE SPECIFICATIONS ON **TELECHRON** SYNCHRONOUS MOTORS FOR USE IN TIMERS, TIME SWITCHES, RECORDING AND CONTROLLING INSTRUMENTS, COST RECORDERS, CYCLE CONTROLLERS, ETC. **TELECHRON INC., 14 UNION ST., ASHLAND, MASS. A GENERAL ELECTRIC AFFILIATE.**

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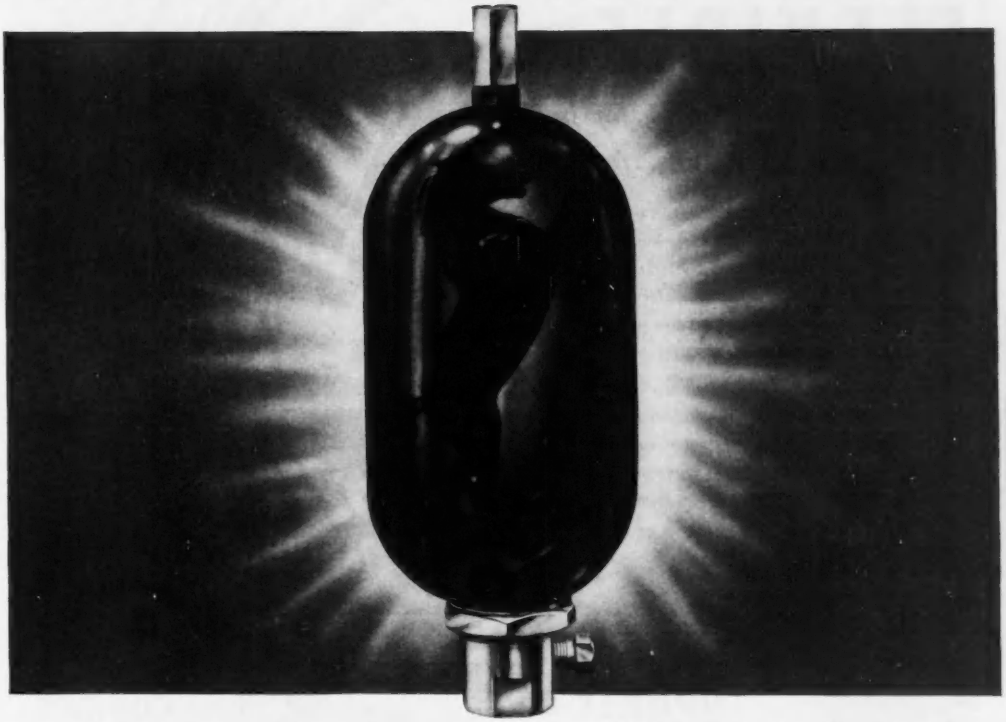
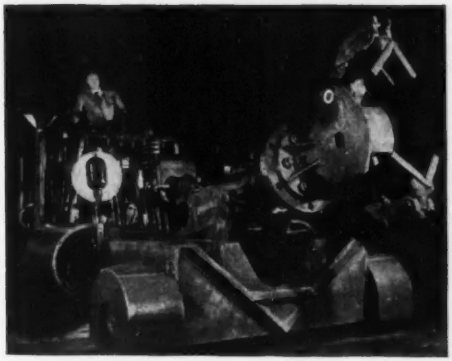


Stored horsepower in Greer Accumulators boosts efficiency of hydraulic systems!



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"Incorporating a Greer Accumulator in our 31,000 pound manipulator saved 9 hours machining time, 1 hour of assembly time, 20% floor space and reduced the actual cost of manufacture", writes S. T. Morgan, chief engineer, Edgar E. Brosius Co. Inc. Pittsburgh.

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Our engineers have had fifty years experience in the design and manufacture of variable-speed controls, and in assisting in the adoption of Lewellen Controls to every type machine and process. Lewellen Controls are available in a hundred standard types and sizes. Hundreds of special problems have been solved in order to meet machine dimensions and various machine conditions. *This is our business. We have no side lines.*

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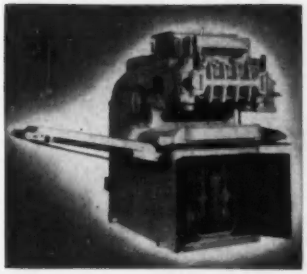
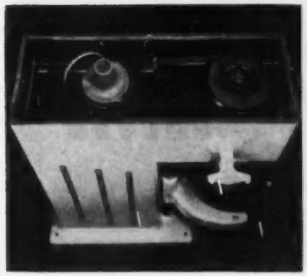
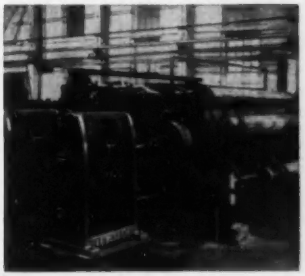
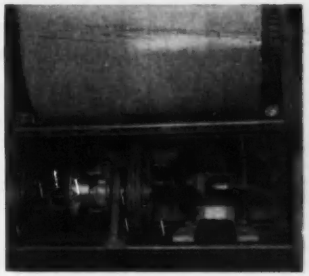
Above: Baker-Perkins Dough Divider
Below: Blakeslee Vertical Mixer



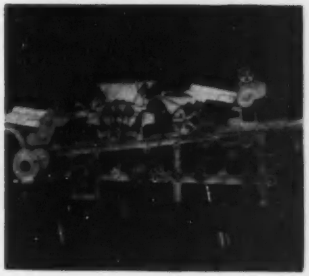


Above: Black-Clawson Paper Cutter
Below: Thos. L. Green Dough Mixer





Above: Thos. L. Green Cracker Embossing Machine
Below: Thos. L. Green Cutting Machine



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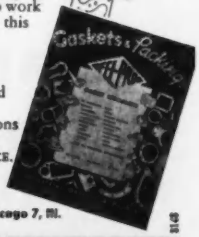

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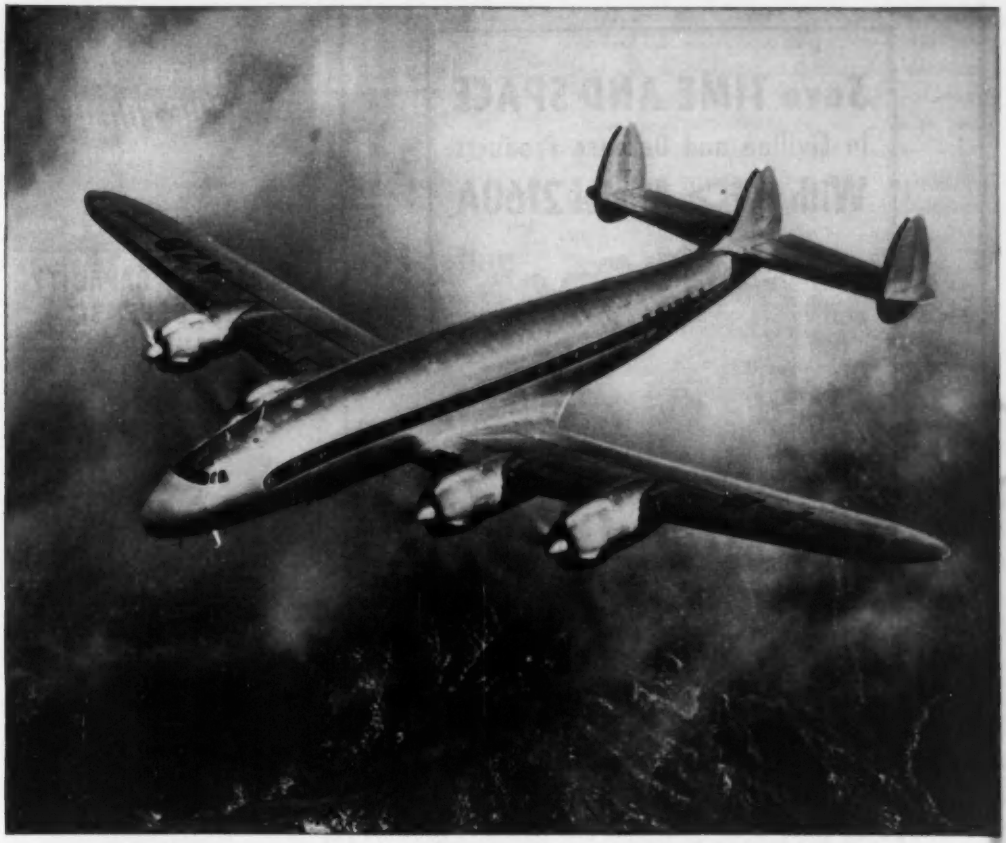

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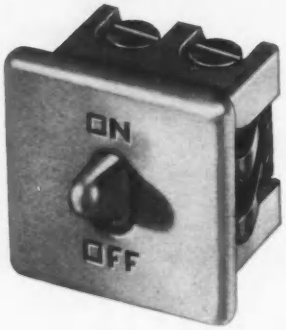

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Write today for complete details on how this new "Diamond H" switch will fit your products.

THE HART MANUFACTURING COMPANY
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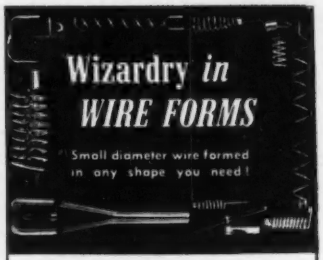

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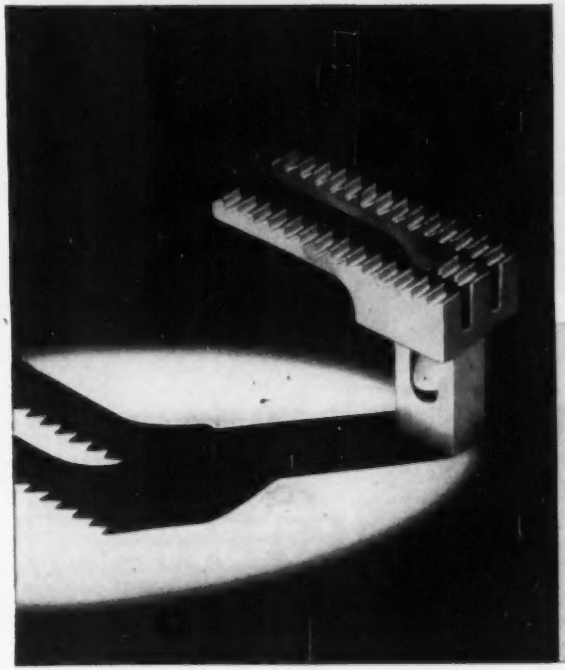

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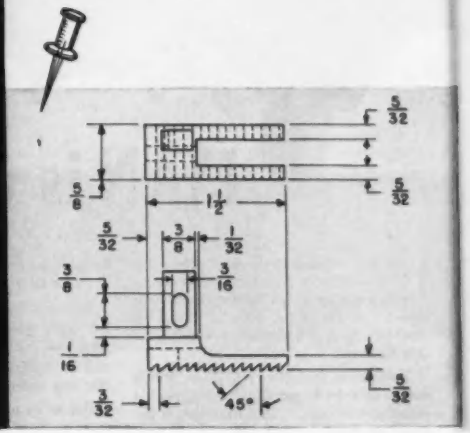

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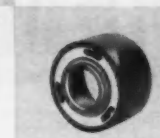

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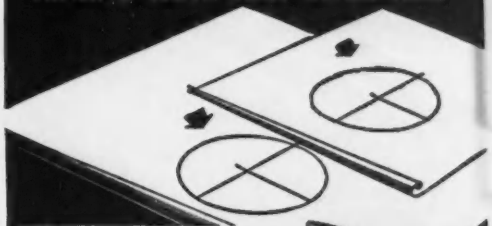

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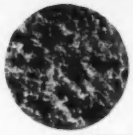	

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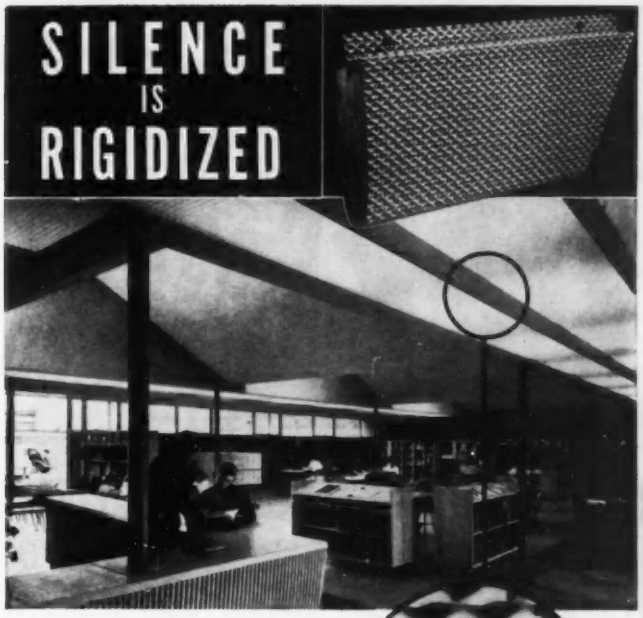

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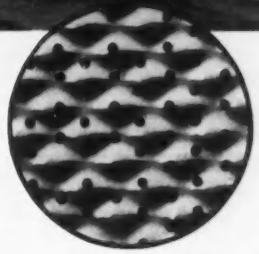

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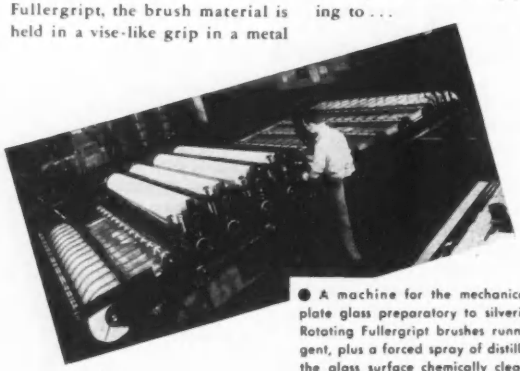

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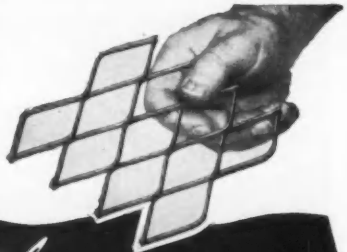

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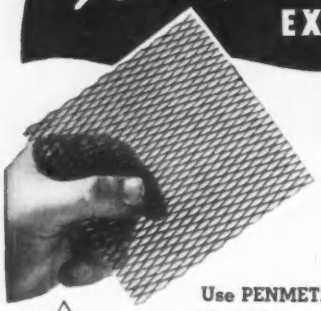

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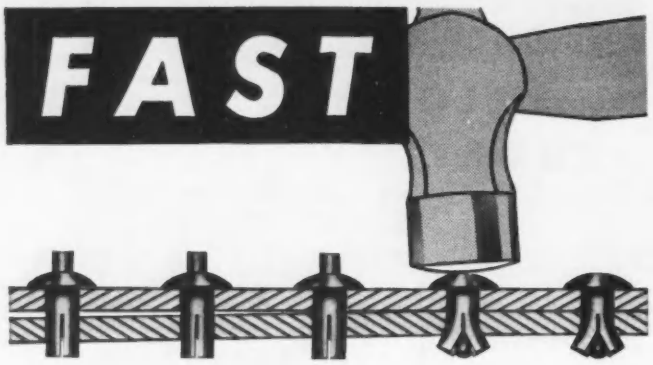

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...it's rotated by rubber covered rolls

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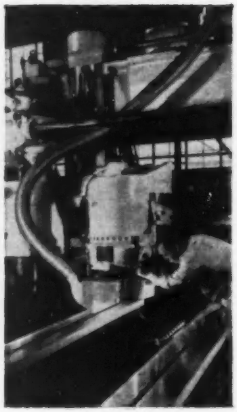
Answers to tough piping, hose and conduit problems can be simple

Hazardous? And how!

Open wiring in grain elevators is forbidden by code requirements. But rigid conduit from switch to motor in this installation would prevent necessary adjustment of the motor drive. SEALTITE* (American Flexible Metal Hose with an impermeable synthetic covering) offered the ideal solution—combining complete safety with flexibility. Photo courtesy Produce Terminal Corporation, Union Stock Yards, Chicago, Ill.



Gulps Grit

The American Flexible Metal Hose shown on this big grinder has plenty of grit—gulps it regularly. It can take it, too, because it's plenty tough as well as flexible. That's a combination of special value in many a job for which this versatile hose should be considered. Photo courtesy Simmons Machine Tool Corporation, Albany, New York.

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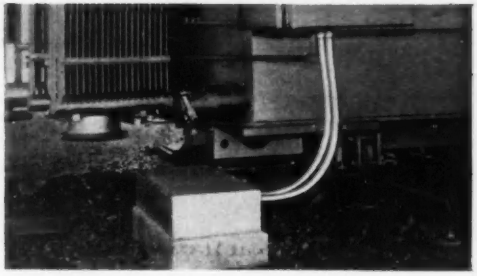

A Neat "Settlement"

They wanted the feed wires to this transformer in conduit. But they expected a settling action might occur which would put a dangerous strain on rigid conduit. So they used SEALTITE*, combining flexibility with complete protection. A neat settlement of a common problem. Photo courtesy Pacific Gas & Electric Company, San Francisco, Calif.

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from mine to consumer

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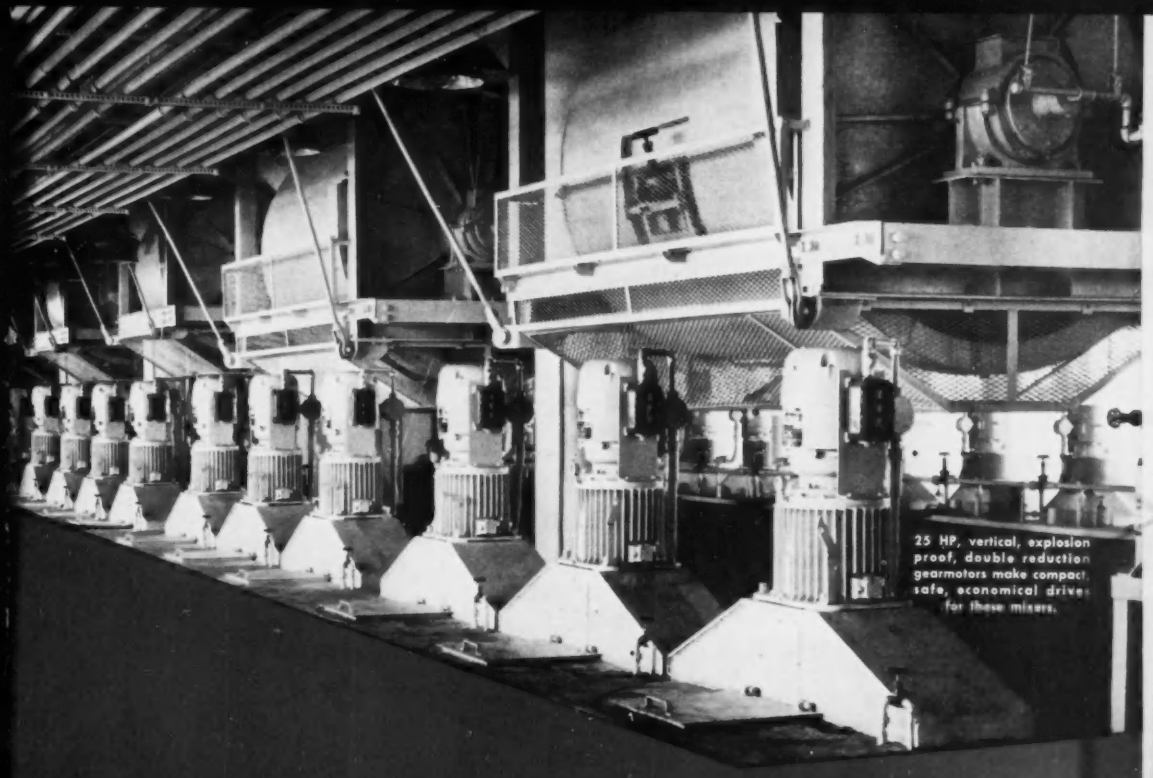

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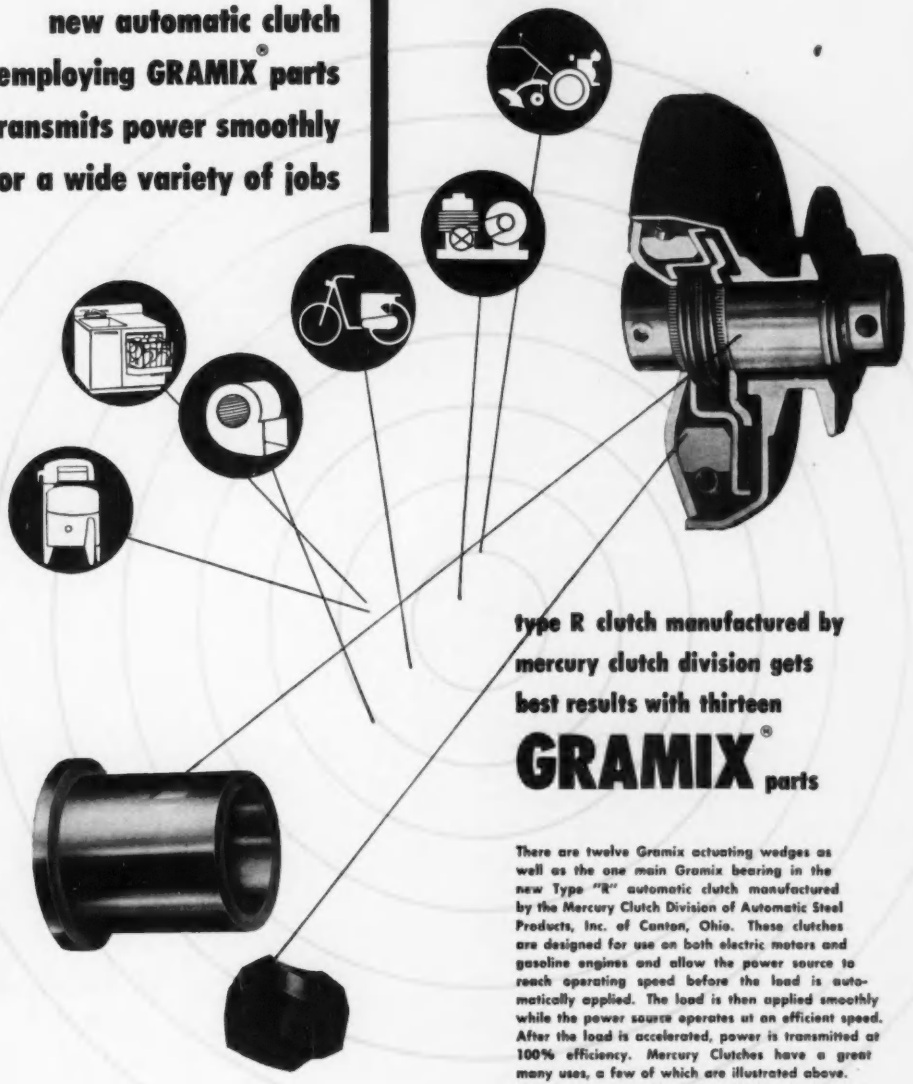
THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO

new automatic clutch employing GRAMIX® parts transmits power smoothly for a wide variety of jobs



type R clutch manufactured by mercury clutch division gets best results with thirteen

GRAMIX® parts

There are twelve Gramix actuating wedges as well as the one main Gramix bearing in the new Type "R" automatic clutch manufactured by the Mercury Clutch Division of Automatic Steel Products, Inc. of Canton, Ohio. These clutches are designed for use on both electric motors and gasoline engines and allow the power source to reach operating speed before the load is automatically applied. The load is then applied smoothly while the power source operates at an efficient speed. After the load is accelerated, power is transmitted at 100% efficiency. Mercury Clutches have a great many uses, a few of which are illustrated above. Gramix is proving ideal not only for clutches but for thousands of other parts in hundreds of products. Gramix powdered metal parts can be die-pressed in relatively intricate shapes to tolerances within .0005". Gramix parts are oil impregnated for self lubrication. They're tough, strong and relatively light in weight. Because they require little or no machining, Gramix parts cost considerably less than identical, machined parts.

To determine whether Gramix can help cut your costs and improve the performance of your product, write today to:

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